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A mi madre

y a la memoria de mi padre

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Berlin, May 2020 *Pablo A. Anaya Longaric*

Declaration of Co-Authorship and Publications

This dissertation consists of four research papers. Three papers were written in collaboration with one or more co-authors. My contribution in conception, implementation and drafting can be summarized as follows:

- Pablo Anaya, Michael Hachula and Christian J. Offermanns:

  Spillovers of U.S. Unconventional Monetary Policy to Emerging Markets: The Role of Capital Flows

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  Contribution: 33 percent

- Pablo Anaya:

  Foreign Currency Exposure and the Financial Channel of Exchange Rates

  Contribution: 100 percent

- Pablo Anaya and Florentine Schwark:

  The Impact of International Capital Flows on Domestic Investment

  Contribution: 50 percent

- Pablo Anaya and Alex Pienkowski:

  The Drivers Public Debt: A Holistic Approach

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  Disclaimer: The views expressed in this chapter are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

  Contribution: 50 percent

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List of Abbreviations

AEs Advanced economies
AIC Akaike information iriterion
BC "Business Cycle" model
BRA Brazil
BIS Bank for International Settlements
CBOE Chicago Board Options Exchange
CDS Credit default swaps
CHL Chile
COL Colombia
CPI Consumer price index
CZE Czech Republic
DSGE Dynamic sStochastic General Equilibrium
ECB European Central Bank
e.g. exempli gratia
EMEs Emerging market economies
FC "Financial Conditions" model
FDI Foreign Direct Investment
FED Federal Reserve Bank
FRED Federal Reserve Bank of St.Louis database
FX Foreign exchange rate
GDP Gross domestic product
GVAR Global vector autoregression
GVECM Global vector error-correction model
HUN Hungary
i.e. id est
IDN Indonesia
IFS International Financial Statistics database
IMF International Monetary Fund

IND India
IP Industrial production
IRF Impulse response function
ISR Israel
KOR South Korea
LP Local Projections
LP-IV Local Projections - Instrumental Variable
MEX Mexico
MSCI Morgan Stanley Capital International
OECD Organisation for Economic Co-operation and Development
PER Peru
PHL Philippines
POL Poland
QE Quantitative easing
REER Real effective exchange rate
RUS Russia
SGP Stability and Growth Pact
SOE Small open economy
SVAR Structural vector autoregression
THA Thailand
TUR Turkey
TIC Treasury International Capital Reporting System
UMP Unconventional monetary policy
UIP Uncovered interest rate parity
U.K. United Kingdom
U.S. United States of America
USA United States of America
USD U.S. Dollars
VAR Vector autoregression
VARX Vector autoregression with exogenous regressors
VIX CBOE volatility index
ZAF South Africa

Summary

The onset of the global financial crisis and the implementation of extraordinarily expansionary monetary policies in many economies triggered a renewed interest in the effects of global and foreign shocks in individual countries. At the same time, the cross-country heterogeneity of the macroeconomic and financial effects of shocks highlighted the need to study closely the factors that affect their propagation. This thesis contains four independent essays which address these issues. The first three chapters share a common theme and investigate the effects of foreign and global shocks in the domestic economy and how the transmission mechanisms of these shocks work. The last essay studies how individual country characteristics, especially that of the exchange rate and monetary arrangement, affect the propagation of domestic shocks that are of first order relevance for debt sustainability analysis.

The first chapter of this thesis is joint work with Michael Hachula and Christian Offermanns. We employ a structural global VAR model to analyze whether U.S. unconventional monetary policy shocks, identified through changes in the central bank's balance sheet, have an impact on financial and economic conditions in emerging market economies (EMEs). Moreover, we study whether international capital flows are an important channel of shock transmission. We find that an expansionary policy shock significantly increases portfolio flows from the U.S. to EMEs, which is accompanied by a persistent movement in real and financial variables in recipient countries. Moreover, EMEs on average respond to the shock with an easing of their own monetary policy stance. The findings appear to be independent of heterogeneous country characteristics like the underlying exchange rate arrangement, the quality of institutions, or the degree of financial openness.

In the second chapter, I investigate the macroeconomic and financial effects of U.S. dollar (USD) exchange rate fluctuations in small open economies. Exchange rate movements affect the economy through changes in net exports, i.e. the trade channel, and through valuation changes in assets and liabilities denominated in for-

eign currencies, i.e. the financial channel. I specifically examine how the financial channel affects the overall impact of exchange rate fluctuations and assess to what extent foreign currency exposure, defined as debt in USD, determines the financial channel's strength. As a novel result, I empirically find that, if foreign currency exposure is high, an appreciation of the domestic currency against the USD is *expansionary* and loosens financial conditions, which is consistent with the financial channel of exchange rates. Moreover, I estimate an open economy New Keynesian model, in which a fraction of the domestic banks' liabilities is denominated in USD. The model shows that an appreciation against the USD can be expansionary depending on the strength of the financial and trade channels, which is linked to the level of foreign currency exposure and trade openness, respectively. Finally, the model also indicates that the financial channel potentially amplifies the effects of U.S. monetary policy shocks, due to the resulting change in the USD exchange rate.

The third chapter, which is joint work with Florentine Schwark, is my latest research project and should be understood as an early draft. In this essay, we assess the relationship between international capital flows and investment. In particular, we aim to understand whether capital flows and its components, i.e. foreign direct investment (FDI), credit, and portfolio flows, affect investment in EMEs and advanced economies (AEs) differently and what drives those differences. Using Local Projections - Instrumental Variable methods, we find that the impact of international capital flows in EMEs is positive, especially that of FDI and credit flows. The effects of international capital flows to and from advanced economies is much weaker and, in these countries, investment is mainly affected by domestic credit conditions. Finally, we find evidence that suggests that financial development accounts for the large differences between the effects of capital flows in EMEs and AEs.

Finally, the last chapter is a joint work with Alex Pienkowski and was written during a research internship at the International Monetary Fund. In this essay, we present an approach to detail the propagation of shocks to public debt. We employ a structural VAR with an endogenous debt accumulation equation to assess how the main drivers of sovereign debt dynamics – the primary balance, the interest rate, growth and inflation – interact with each other. Addressing this question is particularly useful for debt sustainability analysis. We find that some interactions exacerbate the impact of shocks to the accumulation of debt, while others act to

stabilize debt dynamics. Furthermore, the choice of monetary policy regime plays an important role in these debt dynamics – countries with constrained monetary policy, e.g. those with a fixed exchange rate regime, are more at risk from changes in market sentiment and must rely much more on fiscal policy to constrain debt.

Zusammenfassung

Der Beginn der globalen Finanzkrise und die Implementierung einer außerordentlich expansiven Geldpolitik in vielen Volkswirtschaften lösten ein erneutes Interesse an den Auswirkungen globaler und ausländischer Schocks in einzelnen Ländern aus. Zugleich hat die länderübergreifende Heterogenität der makroökonomischen und finanziellen Auswirkungen von Schocks die Notwendigkeit unterstrichen, jene Faktoren, welche die Ausbreitung der Schocks beeinflussen, genau zu untersuchen. Diese Dissertation besteht aus vier unabhängigen Aufsätzen, die sich mit den oben genannten Themen befassen. Die ersten drei Kapitel behandeln ein gemeinsames Thema. Sie untersuchen die Auswirkungen ausländischer und globaler Schocks auf die heimische Wirtschaft sowie die Funktionsweise der Übertragungsmechanismen dieser Schocks. Der letzte Aufsatz analysiert, wie sich einzelne Ländereigenschaften, insbesondere das Wechselkurs- und Geldpolitischensystem, auf die Ausbreitung inländischer Schocks auswirken, die für die Analyse der Schuldentragfähigkeit von Relevanz erster Ordnung sind.

Das erste Kapitel dieser Dissertation ist ein gemeinsamer Aufsatz, der mit Michael Hachula und Christian Offermanns geschrieben wurde. Unter Verwendung eines strukturellen globalen VAR-Modells, untersuchen wir, ob unkonventionelle geldpolitische Schocks in den USA Effekte auf die Finanzmärkte und die wirtschaftliche Situation in Schwellenländern haben. Zur Identifikation der geldpolitischen Schocks benutzen wir die Bilanz der US Zentralbank als Indikatorvariable. Darüber hinaus untersuchen wir, ob internationale Kapitalströme ein wichtiger Kanal der Schockübertragung sind. Unsere Schätzungen ergeben, dass ein expansiver geldpolitischer Schock die Portfolioströme aus den USA in die Schwellenländer signifikant erhöht, was mit einer anhaltenden Bewegung der dortigen realenwirtschaftlichen Variablen und der Finanzmärkte einhergeht. Zudem reagieren Zentralbanken in Schwellenländern auf den Schock im Durchschnitt mit einer Lockerung ihres eigenen geldpolitischen Kurses. Die Ergebnisse scheinen unabhängig von heterogenen Ländereigen-

schaften, wie den zugrunde liegenden Wechselkursvereinbarungen, der Qualität der Institutionen oder dem Grad der finanziellen Offenheit, zu sein.

Im zweiten Kapitel untersuche ich die makroökonomischen und finanziellen Effekte von Wechselkursschwankungen des US-Dollars (USD) in kleinen offenen Volkswirtschaften. Wechselkursbewegungen haben Auswirkungen auf die Wirtschaft durch Veränderungen der Nettoexporte, d.h. durch den Handelskanal, und durch Bewertungsänderungen der in Fremdwährungen lautenden Vermögenswerte und Verbindlichkeiten, d.h. durch den Finanzkanal. Insbesondere untersuche ich, wie der Finanzkanal die Gesamtauswirkung von Wechselkursschwankungen beeinflusst, und bewerte, inwieweit das Fremdwährungsrisiko, definiert als Verschuldung in USD, die Stärke des Finanzkanals bestimmt. Ich stelle empirisch fest, dass bei einem hohen Fremdwährungsrisiko eine Aufwertung der Landeswährung gegenüber dem USD *expansiv* ist, da die finanziellen Bedingungen gelockert werden, was mit dem Finanzkanal der Wechselkurse vereinbar ist. Zudem schätze ich ein Neu-Keynesianisches Modell einer offenen Wirtschaft, bei dem ein Anteil der Verbindlichkeiten der inländischen Banken auf USD lautet. Das Modell zeigt, dass eine Aufwertung gegenüber dem USD je nach Stärke der Finanz- und Handelskanäle expansiv sein kann, was mit der Höhe der Verschuldung in USD und der Handelsoffenheit zusammenhängt. Schließlich weist das Modell auch darauf hin, dass der Finanzkanal, aufgrund damit verbundener Änderungen des USD-Wechselkurses, die Effekte von U.S. geldpolitischen Schocks potenziell verstärkt.

Das dritte Kapitel ist in Zusammenarbeit mit Florentine Schwark entstanden. Es ist mein neuestes Forschungsprojekt und ist als ein früher Entwurf zu verstehen. In diesem Aufsatz bewerten wir die Beziehung zwischen internationalen Kapitalströmen und Investitionen. Insbesondere beschäftigen wir uns mit der Fragestellung, ob Kapitalströme und ihre Komponenten, d.h. ausländische Direktinvestitionen (ADI), Kredit- und Portfolioströme, unterschiedliche Auswirkungen auf Investitionen in Schwellenländern und Industrieländern haben und was diese Unterschiede antreibt. Mittels Local Projections - Instrumental Variables Methoden stellen wir fest, dass die Auswirkungen internationaler Kapitalströme in Schwellenländern positiv sind, insbesondere die der ADI und der Kreditströme. Die Effekte der internationalen Kapitalströme in und aus den Industrieländern sind viel schwächer, und die Investitionen in diesen Ländern werden hauptsächlich von heimischen Kreditbedingungen beeinflusst. Schließlich finden wir Belege dafür, dass die große Differenz zwischen den Auswirkungen von Kapitalströmen in Schwellen- und Industrieländern auf den Entwicklungsgrad des Finanzsystems zurückzuführen ist.

Das letzte Kapitel ist ein gemeinsamer Aufsatz geschrieben in Zusammenarbeit mit Alex Pienkowski. Dieses Papier ist im Rahmen eines Forschungspraktikums bei dem Internationalen Währungsfonds entstanden. In diesem Aufsatz stellen wir einen Ansatz vor, der die Ausbreitung von Schocks auf die Staatsverschuldung detailliert beschreibt. Wir verwenden einen strukturellen VAR mit einer endogenen Schuldenakkumulationsgleichung, um festzustellen, wie die Haupttreiber der Staatsschuldendynamik - Primärsaldo, Zinssatz, Wachstum und Inflation - miteinander interagieren. Diese Fragestellung ist besonders nützlich für die Analyse der Schuldentragfähigkeit. Wir stellen fest, dass bestimmte Interaktionen die Auswirkungen von Schocks auf die Schuldenakkumulation verstärken, während andere zur Stabilisierung der Schuldendynamik beitragen. Darüber hinaus spielt die Wahl des geldpolitischen Systems eine wichtige Rolle bei der Schuldendynamik - Länder mit einer eingeschränkter Geldpolitik, z.B. solche mit einem festen Wechselkurssystem, sind einem größeren Risiko von Veränderungen der Marktstimmung ausgesetzt und müssen sich viel stärker auf die Fiskalpolitik verlassen, um die Verschuldung einzudämmen.

Introduction and Overview

Over the past decades, international trade and financial openness have risen sharply, which provoked a surge in the interest in the cross-border effects of foreign and global shocks among policy makers and academics alike. Moreover, the truly global nature of the 2008 financial crisis and its consequences have strengthen the urge to understand the effects from these shocks and their transmission channels, as well as policy responses to mitigate their adverse effects. At the same time, the cross-country heterogeneity of the macroeconomic and financial effects of shocks highlighted the need to study closely the factors that affect their international and domestic propagation.

This thesis contains four independent essays which address these issues. The first three chapters share a common theme and investigate the effects of foreign and global shocks in the domestic economy and how the transmission mechanisms of these shocks work. More precisely, the first essay of the thesis analyses the effects of U.S. unconventional monetary policy (UMP) on emerging market economies (EMEs). The second essay assesses the effects of USD exchange rate fluctuations in small open economies (SOEs). In particular, it studies to what extent debt in USD affects the overall impact of exchange rates movements on macroeconomic and financial conditions. The third paper, in turn, investigates what are the effects of capital flows on investment in EMEs and advanced economies (AEs) and what accounts for the cross-country differences in those effects. Finally, the last essay addresses a somewhat different issue and studies the propagation of shocks that affect public debt. Specifically, it analyzes whether the exchange rate regime – or monetary policy arrangement – affects how these shocks propagate domestically. Thus, while the focus of this essay is on the domestic effects of fiscal shocks, it also provides a cross-country comparison of these effects and considers the international dimension of this question.

The **first chapter** of this thesis is joint work with Michael Hachula and Christian Offermanns. In this essay, we empirically investigate the effects of U.S. UMP shocks on real and financial key indicators in EMEs. In particular, we analyze whether UMP shocks are a driver of capital flows into EMEs and whether capital flows are an important channel of shock transmission. We structure our analysis into the following consecutive research questions. First, is U.S. UMP related to portfolio flows into EMEs? Second, does U.S. UMP affect financial conditions in EMEs? If so, are portfolio flows an important channel of shock transmission? Third, is the conduct of monetary policy in EMEs in this way influenced by U.S. UMP? To answer these questions, we estimate a structural global vector autoregressive (GVAR) model incorporating both real and financial variables for 39 EMEs and AEs over the period 2008–2014 and evaluate the dynamic responses of these variables to a U.S. UMP shock. We identify the shock with the size of the Fed balance sheet as an unconventional monetary policy instrument and employ zero and sign restrictions, similar to Gambacorta et al. (2014).

Our work is related to two strands of empirical studies that analyze similar questions. First, it is closely linked to studies that assess the determinants of capital flows (Fratzscher, 2012; Forbes and Warnock, 2012) and the relationship between unconventional monetary policy and capital flows (Bruno and Shin, 2015a; Fratzscher et al., 2013). Second, our paper is related to other studies that investigate the spillover effects of U.S. policies (Miranda-Agrippino and Rey, 2015; Georgiadis, 2015a) and their impact on financial and macroeconomic conditions in EMEs (Aizenman et al., 2016).

We contribute to these two lines of the literature by employing a GVAR approach that takes interactions between financial and real variables, both between countries and over time, into account. Given that the international transmission of shocks via financial and trade linkages takes time, this is an important feature that event studies or panel approaches cannot consider. Moreover, our study provides a systematic assessment of U.S. unconventional monetary policy on the global financial cycle (Miranda-Agrippino and Rey, 2015) and on international portfolio flows in a structural GVAR framework, which allows us to quantify the persistent effects of UMP shocks on capital flows and other variables for individual countries.

Our main results can be summarized as follows. First, we find that an expansionary U.S. monetary policy shock significantly increases portfolio outflows from the U.S. for almost two quarters. In the EMEs this is associated with a rise in portfolio inflows. Second, this increase in inflows goes hand in hand with significant real and financial effects in EMEs: real output growth and equity returns increase, and the real exchange rate appreciates. Importantly, portfolio flows prove to be a key channel of transmission between the U.S. and the EMEs in the GVAR specification. Third, we find that, the short-term (policy) interest rate in EMEs declines in response to an expansionary U.S. shock. This result indicates that U.S. policy innovations have an influence on the conduct of monetary policy in EMEs. Regarding cross-country differences in our results, we find that the magnitude of portfolio inflows to EMEs appears to vary with the proximity to the U.S. However, economic country characteristics like the degree of financial openness or the quality of domestic institutions do not affect the countries' response to the UMP shock. In particular, a floating exchange rate arrangement does not appear to provide a better insulation from U.S. spillovers.

The **second chapter** of this thesis deals with one important international transmission mechanism of foreign monetary policy and other global shocks to SOEs, namely USD exchange rate fluctuations (Iacoviello and Navarro, 2019). USD exchange rate movements affect SOEs through changes in the value and volume of exports and imports (the trade channel) and through valuation effects of assets and liabilities denominated in foreign currency (the financial channel). It has been conventional wisdom in international macroeconomics that a domestic appreciation has contractionary effects on the economy due to the resulting decrease in net exports, other things being equal. However, because of the ever higher degree of financial integration, foreign currency exposure has gained more attention (Bénétrix et al., 2015), and therefore the relevance of exchange rate movements operating through the financial channel has increased (Hofmann et al., 2017). Importantly, the financial channel operates mainly through changes in the valuation of the liability side of a country's external balance sheet. Thus, under foreign currency exposure, a domestic appreciation decreases the value of liabilities relative to assets, which strengthens the external balance sheet, loosens financial conditions and ultimately stimulates investment and GDP (Avdjiev et al., 2019).

The aim of this chapter is to empirically assess the macroeconomic and financial effects of USD exchange rate fluctuations in SOEs. In particular, I study how the financial channel affects the overall impact of exchange rate fluctuations, under which conditions it dominates the trade channel, and to what extent foreign currency exposure – defined as liabilities denominated in USD – determines its strength. After showing the effects of the financial channel, I evaluate whether it amplifies or dampens the effects of foreign monetary policy shocks. To answer these research questions, I use Local Projections - Instrumental Variable (LP-IV) methods. Furthermore, to obtain a structural interpretation of the empirical findings and be able to analyze the trade and financial channels in detail, I estimate a small open economy New Keynesian model with financial frictions and currency mismatch in the banks' balance sheets.

My essay is related to studies that assess the macroeconomic effects of exchange rate movements in EMEs and AEs using SVAR (Kim and Ying, 2007; Fratzscher et al., 2010; Forbes et al., 2018) and local projections (Lane and Stracca, 2017). Moreover, it is closely linked to empirical papers that explicitly consider the financial channel of exchange rates as an important transmission channel of USD exchange rate shocks (Avdjiev et al., 2019; Hofmann et al., 2017; Bruno and Shin, 2015b). Finally, this essay extends the work by by Aoki et al. (2016), Akinci and Queralto (2018), and Mimir and Sunel (2019), who study the effects of foreign shocks and the implementation of optimal policy responses in calibrated open economy DSGE models with currency mismatch in the bank's liabilities.

I contribute to the literature by systematically assessing the determinants of the strength of the financial and trade channels. I perform this analysis both empirically and with a theoretical model. One of the main contributions in the empirical part is the novel identification scheme for USD exchange rate shocks to individual SOEs. For this purpose, I construct shocks to the UIP equation between the U.S. and other major economies. These shocks are exogenous to the individual SOEs that I analyze and at the same time prove to be a valid instrument for the bilateral exchange rates between the USD and the SOEs' currencies.

My empirical results show that if foreign currency exposure is high, an appreciation of the domestic currency against the USD is *expansionary* as it loosens financial conditions and increases investment, which is consistent with the financial channel of exchange rates. In line with the empirical results, the estimated New Keynesian model indicates that the level of foreign currency exposure is an important factor behind the strength of the financial channel. Moreover, the model shows that it is the interaction between foreign currency exposure and trade openness, i.e. between the financial and trade channels, the determinant of the effects of an exchange rate appreciation in SOEs. Finally, I also find that the financial channel potentially amplifies the effects of U.S. monetary policy shocks.

These results have several important implications. First, as I show in the paper, the financial channel could change how exchange rate fluctuations affect SOEs, since it works in the opposite direction of the trade channel. Thus, analyzing the effects of exchange rate movements without considering the financial channel could be misleading. Further, the financial channel has a significant impact on financial conditions and potentially amplifies the effects of foreign shocks. Therefore, policy makers concerned with these two issues should take the financial channel into account when designing and implementing policies.

The **third chapter**, which is joint work with Florentine Schwark, is my latest research project and should be understood as an early draft. Again, motivated by the large and volatile capital inflows and outflows in the aftermath of the financial crisis, we assess the relationship between international capital flows and investment. In particular, we aim to understand whether capital flows and its components, i.e. foreign direct investment (FDI), credit, and portfolio flows, affect investment in EMEs and AEs differently, and what drives those differences. To answer these questions, we use Local Projections - Instrumental Variable methods, and to address the potential endogeneity of capital flows, we follow Mody and Murshid (2005) and construct an instrument based on the weighted sum of capital flows into and out of a region. This instrument is strongly correlated with capital flows into and out of an individual country, and at the same it is likely that it is exogenous to single countries in our sample (Mody and Murshid, 2005; Mileva, 2008).

This chapter is related to the extensive literature on the effects of capital flows on EMEs, which mostly focused on periods before the global financial crisis (Bosworth and Collins, 1999; Mody and Murshid, 2005; Mileva, 2008). All these previous studies highlighted the significant positive effects of FDI inflows on investment. Moreover, our study is also related to studies on the cost and benefits of financial account liberalization (Rodrik, 1998; Bhagwati, 1998; Kose et al., 2011). Finally, our essay is linked to studies on the connection between financial development and investment (Levine, 2005; Xu, 2000). We contribute to this literature by taking a fresh look at the data and systematically examining which factors account for the difference in the impact of capital flows on investment across countries.

We find that the impact of international capital flows on investment in EMEs is positive, especially that of FDI and credit flows. The effects of international capital flows to and from advanced economies is much weaker and, in these countries, investment is mainly affected by domestic credit conditions. We also find evidence that suggests that financial development accounts for the large differences between the effects of capital flows in EMEs and AEs. However, since this essay is work in progress, we still have to address several issues. For instance, we do not have a clear, structural explanation why financial development weakens the effects of capital flows on investment. Moreover, we do not explore other potential factors that could affect the international capital flows - investment relation, such as institutional quality, quality of policies (Mody and Murshid, 2005), exchange rate arrangements and competitiveness, or cross-industry differences in access to domestic and foreign finance and foreign markets (Igan et al. (2016)). Finally, we point out that domestic credit conditions appear to matter more for AEs than for EMEs. To explore this important issue in detail, we need to extend our analysis and also identify a exogenous shocks to domestic financial conditions. Thus, this essay's conclusions should be taken carefully.

Finally, the **last chapter** is a joint work with Alex Pienkowski and was written during a research internship at the International Monetary Fund. This work is motivated by the steep increase in public debt witnessed after the global financial crisis. As a consequence to this, concerns over sovereign debt sustainability have led to significant financial and economic disruption, and the optimal policy response to these elevated debt levels is a topic of controversy among policymakers and academics. In this essay, we assess the propagation of shocks to public debt, and specifically analyze whether the exchange rate regime – or monetary policy arrangement – affects how these shocks propagate domestically. To do so, we employ a structural VAR model with an endogenous debt accumulation equation to assess how the main drivers of sovereign debt dynamics – the primary balance, the interest rate, growth and inflation – interact with each other.

Our work builds on a vast literature on the effects of fiscal shocks on debt and economic performance. First, this chapter is linked to studies that assess whether the primary balance reacts to exogenous changes in debt (Bohn, 1998, 2005; Abiad and Ostry, 2005). Second, this essay is linked to studies that analyze the effects of shocks to government spending, taxes or the primary balance on debt and GDP (Blanchard and Perotti, 1999; Favero and Giavazzi, 2007; Cherif and Hasanov, 2018). We contribute to the literature by taking a holistic approach and study the effects of several drivers of public debt and their interaction, which is particularly useful for debt sustainability analysis. Moreover, we systematically study to what extent the choice of different monetary policy or exchange rate arrangement affects the economic responses to fiscal shocks. We find that some interactions exacerbate the impact of shocks to the accumulation of debt, while others act to stabilize debt dynamics. Furthermore, the choice of monetary policy regime plays an important role in these debt dynamics – countries with constrained monetary policy, e.g. those with a fixed exchange rate regime, are more at risk from changes in market sentiment and must rely much more on fiscal policy to constrain debt.

CHAPTER 1

Spillovers of U.S. Unconventional Monetary Policy to Emerging Markets: The Role of Capital Flows[1]

1.1 Introduction

Since the onset of the global financial crisis, large and volatile capital flows into emerging market economies (EMEs) have triggered a renewed interest in the determinants and consequences of such cross-border flows. A growing literature perceives a "global financial cycle" to be a key determinant of capital flows into EMEs (see Nier et al., 2014). This cycle is described as co-movement in gross capital flows, credit conditions, and asset prices across countries (see Rey, 2013, or Passari and Rey, 2015).[2] Rey (2013, 2016) argues that one of the main drivers of the cycle is monetary policy by the U.S. Federal Reserve, whose interest rate decisions are transmitted to EMEs' financial conditions through international capital flows. Moreover, she reasons that, as a consequence, U.S. interest rate decisions influence the conduct of monetary policy in EMEs. Responding to the financial crisis and the subsequent sluggish recovery, however, the Federal Reserve (Fed) repeatedly engaged in uncon-

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[2]Passari and Rey (2015) and Miranda-Agrippino and Rey (2015) provide evidence for the existence of a global financial cycle by showing that prices of stocks and other risky assets as well as credit, leverage, and gross capital flows around the world are related to a common global factor.

ventional monetary policy measures such as large-scale asset purchases. While many studies analyze how conventional interest rate policy by the Fed can drive financial conditions globally (see, among others, Miranda-Agrippino and Rey, 2015, or Bruno and Shin, 2015a), results on unconventional measures are rather scarce.

In this paper, we provide new evidence on the global role of U.S. monetary policy by empirically investigating the effects of U.S. unconventional monetary policy (UMP) shocks on real and financial key indicators in EMEs. In particular, we analyze whether UMP shocks are a driver of capital flows into EMEs and whether capital flows are an important channel of shock transmission. In this regard, Bruno and Shin (2015a) establish a link between U.S. monetary policy and international banking flows for the period 1995–2007. However, Shin (2013) presents evidence that banking flows strongly diminished since the beginning of the financial crisis. Instead, bond and equity flows to EMEs increased heavily. Accounting for this change in the capital flow composition, we evaluate whether portfolio bond or equity flows play a pivotal role in transmitting U.S. UMP shocks to EMEs.

We structure our analysis into the following consecutive questions. First, is U.S. UMP related to portfolio flows into EMEs? Second, does U.S. UMP affect asset prices and exchange rates (henceforth: financial conditions) in EMEs? If so, are portfolio flows an important channel of shock transmission? Third, is the conduct of monetary policy in EMEs in this way influenced by U.S. UMP? To answer these questions, we estimate a structural global vector autoregressive (GVAR) model incorporating both real and financial variables for 39 advanced and emerging market economies over the period 2008–2014 and evaluate the dynamic responses of these variables to a U.S. UMP shock. Identification of the UMP shock is based on the approach of Gambacorta et al. (2014): we use the size of the Fed balance sheet as an unconventional monetary policy instrument and employ a mixture of zero and sign restrictions to distinguish exogenous policy changes from endogenous reactions to other shocks.

To provide a general assessment of these questions, we turn to the panel dimension of the EMEs included in our sample and average over the estimated impulse response functions. Given that existing studies on international capital flows (see below) often find a substantial degree of heterogeneity in the responses of individual countries to various pull and push factors, we then also investigate whether specific economic country characteristics are associated with diverging responses to the UMP shock across country groups.[3]

Our work is related to two lines of empirical studies that address similar questions. First, it is linked to studies that analyze the determinants of capital flows to EMEs (see, among many others, Fratzscher, 2012, or Forbes and Warnock, 2012). More closely, it relates to those studies that explicitly analyze the impact of the Fed's unconventional monetary policy on international capital flows. One set of papers analyzes this question in cross-country panel frameworks (Moore et al., 2013, Koepke, 2014, Lim et al., 2014, Ahmed and Zlate, 2014, Lo Duca et al., 2016). Other studies employ high frequency and event study approaches assessing the relationship in selected windows around policy events (International Monetary Fund, 2013, Rai and Suchanek, 2014, Fratzscher et al., 2013).[4] Second, our work is connected to studies that investigate the effect of U.S. unconventional monetary policy on EMEs financial and real conditions in event studies or comparable frameworks (Eichengreen and Gupta, 2015, Bowman et al., 2015, Aizenman et al., 2016).

We contribute to these two strands of the literature by employing a global VAR approach that takes interactions between financial and real variables both between countries and over time into account. Given that the international transmission of shocks via financial and trade linkages takes time, this is an important feature that existing event studies or panel approaches do not account for. Moreover, our study provides a systematic assessment of U.S. unconventional monetary policy on the global financial cycle and international portfolio flows in a VAR framework, where the policy shock is structurally identified. It thus allows quantifying the persistent effects of UMP shocks on capital flows and other variables for individual countries.

[3] Thereby, a special emphasis is given to how responses differ with respect to the countries' exchange rate regimes. This is motivated by the classical "trilemma", which states that countries can only have two of the following three policy options: independent monetary policy, free capital flows, or a fixed exchange rate. Hence, countries that let their currency float freely might have potentially more leeway to set interest rates independently of the U.S. and, in turn, might be able to buffer foreign shocks better. For further discussion, references, and empirical evidence on the trilemma, see Obstfeld et al. (2005), Klein and Shambaugh (2015), or Aizenman et al. (2016).

[4] Only a few studies employ VAR models, and in those studies capital flows are usually aggregated across countries (see Dahlhaus and Vasishtha, 2014, or Tillmann, 2016). Our approach differs from these models as we analyze the effect of U.S. UMP on capital flows and real and financial variables for individual economies, accounting for trade and financial relations in a global model.

Conceptually, the paper compares directly to the fast growing literature on the global effects of monetary policy shocks in structural VAR or GVAR frameworks (see, among others, Miranda-Agrippino and Rey, 2015, Passari and Rey, 2015, Georgiadis, 2015a, Georgiadis, 2015b, or Chen et al., 2015). For instance, Miranda-Agrippino and Rey (2015) show that conventional U.S. monetary policy is linked to a global factor in risky asset prices and cross-border credit flows. Passari and Rey (2015) and Rey (2016) provide evidence for an effect of conventional U.S. monetary policy on financial conditions in a few small open advanced economies. Closest to our paper is a study by Chen et al. (2015) who also investigate spillovers from U.S. unconventional monetary policy on a number of variables in several AEs and EMEs in a GVAR framework. We complement their work by analyzing the role of capital flows[5] as an important channel of transmission of U.S. monetary policy shocks and by addressing the debate on the global financial cycle as we consider a broad set of EME financial indicators. Moreover, we differ from their approach by directly using an policy instrument, the size of the balance sheet, to identify unconventional monetary policy innovations.

Our main results can be summarized as follows. First, we find that an expansionary U.S. monetary policy shock, associated with an exogenous innovation to the Fed balance sheet, significantly increases portfolio outflows from the U.S. for almost two quarters. In the EMEs this is, on average, associated with a rise in portfolio inflows. Second, this increase in inflows is accompanied by significant real and financial effects in EMEs. In response to the UMP shock, real output growth and equity returns increase, and the real exchange rate appreciates. Importantly, portfolio flows prove to be a key channel of transmission between the U.S. and the EMEs in the GVAR specification. Third, with regard to domestic monetary policy, we find that on average, the short-term (policy) interest rate in EMEs declines in response to an expansionary U.S. shock. This result indicates that U.S. policy innovations have an influence on the conduct of monetary policy in EMEs. Regarding potential differences of our results across countries, we find that the magnitude of portfolio inflows to EMEs appears to vary with the proximity to the U.S. However, economic country characteristics like the degree of financial openness or the quality of domestic institutions do not affect the countries' response to the UMP shock. In

[5]Henceforth we will use the terms "capital flows" and "portfolio flows" interchangeably.

particular, a floating exchange rate arrangement does not appear to provide a better insulation from U.S. spillovers.

The remainder of the paper is structured as follows. In Section 1.2, we outline transmission channels through which U.S. UMP can affect international portfolio flows and structure our empirical analysis into three hypotheses along the research questions. Section 1.3 comprises a description of the data and of the GVAR specifications. In Section 1.4, we present our main results and a sensitivity analysis, and study the role of country characteristics. Section 1.5 concludes.

1.2 UMP, portfolio flows, and financial conditions in EMEs

In our analysis, we are interested in how U.S. UMP shocks affect financial conditions in EMEs, i.e. we analyze the time period during and after the financial crisis. Moreover, we investigate whether international capital flows are an important channel of shock transmission. Shin (2013) presents evidence that during and after the financial crisis direct (portfolio) bond and equity flows play a pivotal role in capital flows to EMEs. In contrast, the formerly dominant international banking flows strongly diminished since the beginning of the crisis. Therefore, we focus our analysis on the role of portfolio flows as an important transmission channel of UMP shocks.[6]

From a theoretical perspective, there are several channels through which the Fed's UMP can affect portfolio allocation decisions by asset managers with a global reach and hence, international portfolio flows (see, e.g., Fratzscher et al., 2013). In principle, they are all linked to the potential domestic transmission channels of UMP brought forward by the literature (for a review, see Joyce et al., 2012). First and foremost, a portfolio balance channel is often emphasized. A Fed purchase of e.g. U.S. Treasury bills crowds out private investment from this market segment. In turn, investors rebalance their portfolio and move to close substitute assets. Ultimately, a chain of rebalancing is set in motion which may affect the allocation of assets across

[6]The arguments of Shin (2013) are in detail laid out in Azis and Shin (2015). A summary of the evidence given by Shin (2013) can also be found in the working paper version of this chapter. We do not additionally consider banking flows in the estimations for two reasons. First, the reviewed stylized facts indicate that the importance of banking flows has strongly diminished since the beginning of the global financial crisis. Second, banking flows are available only at a quarterly frequency. Given the short time period covering the financial crisis and UMP, we do not have enough quarterly observations for a meaningful estimation of their role after the crisis.

countries. Second, the UMP measures can affect the risk appetite of investors, often termed “confidence or risk-taking” channel. While theoretical descriptions of this channel are often rather informal, Bekaert et al. (2013) provide empirical evidence that conventional monetary policy in the U.S. significantly impacts on financial market risk taking. An increased risk appetite might drive investors into more risky high-yield EME assets. Third, UMP might work through a signaling channel. If the Fed’s measures are understood by markets as keeping future interest rates low for a period longer than previously expected, this can affect asset prices by lowering the risk-neutral price component of (future) interest rates. This induced fall in yields on securities in the U.S. can, in turn, lead to an increase in capital flows to EMEs due to a “search-for-yield”.[7]

Foreshadowing our UMP shock identification strategy (see Section 1.3.3), our approach is linked more closely to transmission channels which imply effects not only from the policy announcement, but also from the actual policy implementation. This feature is particularly relevant for the portfolio balance channel, where the available supply of assets is changed through actual purchases. Regarding the other channels, the consideration of actual purchases is often criticised as an incomplete view on the effects of UMP. This objection claims that, since amount and timing of the Fed’s UMP – in the form of large-scale asset purchase programs – were transparently communicated, efficient markets should have fully processed the information when it was announced. However, as Fratzscher et al. (2013) argue, there are two important points against this notion. First, many UMP measures were installed precisely because markets were not functioning. Hence, mere announcements may have been less important than actual purchases because the latter ones restored liquidity

[7]It has to be emphasized that these channels are not mutually exclusive and may rather be at work simultaneously (see Fratzscher et al., 2013) and we do not aim at disentangling them in this paper. Moreover, all of them imply to some extent falling yields in the U.S. and subsequent capital outflows related to a search for yields and an increase in risk appetite. The signaling channel, however, potentially also allows for a negative effect of UMP on capital flows. If new UMP measures are understood as indicating that economic conditions are worse than expected, this might induce a flight to safety and a decrease in capital outflows to EMEs as investment in these countries is perceived as being risky. Hence, in our empirical implementation, we do not impose a sign restriction on the effect of UMP on U.S. bond and equity outflows. As pointed out by an anonymous referee, also note that the different channels potentially induce a different timing in the response of capital flows and financial markets. In our empirical analysis, we therefore also conduct a counterfactual exercise that showcases the importance of capital flows for the transmission of the UMP shock to other variables in the estimated model.

and allowed investors to adjust their exposure. Second, even if market expectations were fairly precise about the actual amount and timing of the purchases, still the expectations about effectiveness of the actual UMP measures might not have been accurate. In their empirical analysis, Fratzscher et al. (2013) show that Fed operations, such as purchases of Treasury securities, indeed had larger effects on the portfolio decisions than Fed announcements of these programs.

Based on the discussion outlined in the introduction and this section, we summarize our research questions for the empirical analysis in three hypotheses in logical order. We will then interpret our estimation results along these hypotheses.

Hypothesis 1: *U.S. UMP affects portfolio outflows from the U.S., and, in turn, portfolio inflows into EMEs.*

If Hypothesis 1 holds true, our estimated model should show an increase in portfolio outflows from the U.S. and in portfolio inflows to EMEs after an expansionary UMP shock as implied by the three channels discussed above.

The second hypothesis links the response of U.S. portfolio flows to the debate on whether and how U.S. monetary policy determines financial conditions globally. In order to test both for effects and their cause, we split the hypothesis into two parts:

Hypothesis 2: *U.S. UMP drives financial conditions in EMEs (**2a**) and portfolio flows are an important channel of transmission (**2b**).*

The first part, Hypothesis 2a, is supported by our results if we find that variables which reflect financial conditions in EMEs significantly react in response to a U.S. UMP shock. Thereby, we assess financial conditions in our analysis using equity returns, to capture general financial market developments, and the foreign exchange rate. In response to an expansionary U.S. UMP shock, equity returns should increase and the currency should appreciate with respect to the U.S. dollar. For the second part, Hypothesis 2b, to hold true portfolio flows should constitute an important channel of transmission of U.S. UMP to EMEs in the empirical specification. In this regard, estimation results in the GVAR should not solely be driven by other transmission channels potentially related to a U.S. UMP shock like demand effects e.g. by an increase in trade with the U.S., or an increase in global growth. We address this issue in estimating the GVAR allowing for different channels of transmission, see Sections 1.3.3 and 1.3.5.

Finally, the third hypothesis focuses on how domestic monetary policy in EMEs reacts to the UMP shock. It connects our estimations to the discussion on whether and how U.S. monetary policy influences the conduct of monetary policy in other countries (see, e.g., Rey, 2013, or Klein and Shambaugh, 2015). By similarly splitting the hypothesis into two parts, we investigate the role of portfolio flows for this effect:

Hypothesis 3: *U.S. UMP has a significant impact on EMEs' monetary policy (**3a**) and portfolio flows are an important channel of transmission (**3b**).*

The first part, Hypothesis 3a, is supported by our results if we find that policy rates in EMEs significantly react in response to a U.S. UMP shock. In particular, we expect policy rates in EMEs to be lowered despite the easing of real and financial conditions, mirroring the expansionary U.S. UMP shock as a consequence of the increase in portfolio flows from the U.S. to EMEs (Hypothesis 3b).

In the empirical analysis, we first generally assess these hypotheses for our panel of countries by averaging the estimated impulse response function across all EME countries. We then also analyze whether economic characteristics of the countries, like the exchange rate regime or the quality of institutions, lead to heterogeneity in the results.

1.3 Data and empirical methodology

1.3.1 Data

We use monthly data on U.S. portfolio bond and equity asset outflows and EMEs financial and real conditions from January 2008 to December 2014. The sample captures the period in which the Fed conducted measures of unconventional monetary policy. Our source of bond and equity flows are the monthly estimates of changes in U.S. holdings of foreign securities provided by the Federal Reserve Board. The dataset is based on estimations that combine two different types of data reported by the Treasury International Capital Reporting System (TIC). On the one hand, data is based on annual benchmark surveys of U.S. holdings of foreign securities. On the other hand, transaction data from mandatory monthly TIC surveys, filed by U.S. banks, securities dealers, and other entities that report net purchases of foreign assets by U.S. residents, is used.[8] The dataset covers portfolio investment in long-term securities, specifically debt instruments with greater-than-one-year original maturity (bonds), and equities. It is widely used in the literature on studying foreign flows into U.S. securities and U.S. flows into foreign securities and considered as highly accurate (see, e.g., Curcuru et al., 2010, or Hanlon et al., 2015).

Such a large and comprehensive dataset on bilateral capital flows is available only for flows out of the U.S.. For the purpose of our analysis, this is not a major concern as we are interested in the effects of U.S. monetary policy that should affect flows from the U.S. more heavily than bilateral flows involving third countries. Moreover, U.S. portfolio flows are of major relevance for the emerging market economies that we study. According to data from the 2012 Coordinated Portfolio Investment Survey, U.S. investors account for more than a third of all cross-border investment in bonds and equities of emerging market economies (see Bertaut and Judson, 2014). The dataset assigns foreign investment of U.S. investors to the country where the entity issuing the security is legally a resident. Hence, it accounts for the so-called 'transaction bias', where the investment is assigned wrongly to the financial center in which the transaction takes place. However, the dataset cannot account for the issuance of securities by EME firms through subsidiaries residing in financial centers. Empirical evidence shows that emerging market firms have increasingly issued debt through foreign subsidiaries in the UK, Ireland, Luxembourg, and other (off-shore) financial centers (see Department of the Treasury, Federal Reserve Bank of New York and Board of Governors of the Federal Reserve System, 2016). This implies that our approach yields estimates which should be interpreted as a lower bound of the effects of U.S. UMP on EMEs.

Further data on EMEs' real and financial conditions is obtained from Thomson Reuters Datastream and the IMF's International Financial Statistics (IFS) database, in particular gross domestic product (GDP), industrial production (IP), consumer

[8] Bertaut and Tryon (2007) for the period 1994–2010 and Bertaut and Judson (2014) for the period 2011–2014 combine the monthly transaction data with the yearly survey data to obtain estimates on monthly levels for both flows and valuation changes. The data can be accessed at the following website: http://www.federalreserve.gov/pubs/ifdp/2014/1113/default.htm. The estimated monthly flows are subject to several adjustments to reduce the noise and biases in the underlying monthly TIC flow data. The necessary steps are in detail described in Bertaut and Tryon (2007) and Bertaut and Judson (2014). We employ only the data on flows and not on valuation changes, since we are only interested in investors' decisions following the UMP shock.

price index (CPI), equity prices, exchange rates, interest rates, commodity prices and foreign exchange reserves. Data on U.S. GDP, IP and CPI as well as the Fed balance sheet and the option-implied volatility index VIX is taken from the Federal Reserve Bank of St. Louis database (FRED). Time series with monthly observations for real GDP are constructed by interpolating the quarterly figures with the monthly index of industrial production, using the method of Chow and Lin (1971). All variables in nominal terms have been converted to real terms prior to the estimation using domestic CPI. Detailed information on data sources and transformations is given in Table 1.A.1 (Appendix 1.A).

Selection of emerging market countries into the sample is driven by different considerations. First, we do not include countries that have limited access to global financial markets and hardly issue securities and equities globally. Second, we only add countries with comprehensive monthly data on economic and financial conditions available. Third, we exclude China as it plays a distinct role through its trade and financial linkages to the U.S. and its particular institutional settings. Nevertheless, the dataset covers a broad range of EMEs and closely resembles the sample of many studies on emerging markets (see, for instance, Bowman et al., 2015, or, Aizenman et al., 2016). Ultimately, our sample contains the following 19 countries: Argentina, Brazil, Chile, Colombia, Hungary, India, Indonesia, Israel, Korea, Mexico, Malaysia, Peru, the Philippines, Poland, Russia, Singapore, South Africa, Thailand, and Turkey. In addition, we add 16 advanced economies to the model to account for trade and financial linkages between them and the included EMEs.[9]

1.3.2 The GVAR model

To analyze the effects of U.S. UMP on a broad set of EMEs while taking all potential cross-country interlinkages into account, in principle, a large scale vector autoregressive (VAR) model of the following form would be adequate:

$$\boldsymbol{y}_t = \boldsymbol{\mu} + \boldsymbol{\lambda} t + \boldsymbol{\Gamma}_1 \boldsymbol{y}_{t-1} + \boldsymbol{\Gamma}_2 \boldsymbol{y}_{t-2} + ... + \boldsymbol{\Gamma}_p \boldsymbol{y}_{t-p} + \boldsymbol{\nu}_t \tag{1.1}$$

[9]The added AEs are Australia, Belgium, Canada, Germany, Denmark, Finland, France, Hong Kong, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the UK. Our model is specified and estimated for the AEs (except the U.S.) in the same way as for the EMEs.

where $\boldsymbol{y}_t = (\boldsymbol{y}'_{1t}\ \boldsymbol{y}'_{2t}\ \dots\ \boldsymbol{y}'_{Nt})'$ denotes the vector of k endogenous variables stacked across N countries for $t = 1, 2, ..., T$ time periods, $\boldsymbol{\Gamma}_s$, $s = 1, 2, ..., p$ denotes an $(Nk \times Nk)$ matrix of coefficients, $\boldsymbol{\mu}$ and $\boldsymbol{\lambda}$ denote $Nk \times 1$ vectors of constant and trend coefficients, and $\boldsymbol{\nu}_t = (\boldsymbol{\nu}'_{1t}\ \boldsymbol{\nu}'_{2t}\ \dots\ \boldsymbol{\nu}'_{Nt})'$ represents shocks. While the model can accommodate a rich structure of cross-country interrelations, estimation of this model under a fully flexible parametrization is not feasible due to the large number of parameters, even for moderate sizes of N.

Dees et al. (2007) employ a parsimonious way of re-specifying this model by modeling the relations between countries via their bilateral trade linkages (the "global VAR" (GVAR) approach). For estimation, the GVAR model is represented by a set of linked country VAR models with exogenous regressors (VARX) for each country $i = 1, 2, ..., N$

$$\boldsymbol{y}_{it} = \sum_{s=1}^{p} \boldsymbol{A}_{is}\boldsymbol{y}_{it-s} + \sum_{s=0}^{p} \boldsymbol{B}_{is}\boldsymbol{y}^*_{it-s} + \sum_{s=0}^{p} \boldsymbol{C}_{is}\boldsymbol{d}_{t-s} + \boldsymbol{\lambda}_i t + \boldsymbol{\mu}_i + \boldsymbol{\varepsilon}_{it}, \tag{1.2}$$

where $\boldsymbol{y}_{it}$ is a vector of k endogenous variables and $\boldsymbol{y}^*_{it}$ is a vector of k country-specific (weakly exogenous) "foreign variables".[10] In order to take account of potential observed common factors (in addition to unobserved common factors captured by the foreign variables), the models include the k_d-dimensional vector $\boldsymbol{d}_t$ of "global" variables affecting every country. The coefficient matrices $\boldsymbol{A}_{is}$, $\boldsymbol{B}_{is}$ and $\boldsymbol{C}_{is}$, $s = 0, 1, 2, ..., p$, as well as the coefficient vectors $\boldsymbol{\lambda}_i$ and $\boldsymbol{\mu}_i$ are of suitable dimension.

The key feature of this approach is to define the so-called foreign variables, $\boldsymbol{y}^*_{it}$, as weighted averages of other countries' variables with bilateral weights w_{ij}:

$$\boldsymbol{y}^*_{it} = \sum_{j=1}^{N} w_{ij}\boldsymbol{y}_{jt}, \qquad \sum_{j=1}^{N} w_{ij} = 1, \quad w_{ij} \geq 0\ \forall\, i, j, \quad w_{ii} = 0. \tag{1.3}$$

The weights capture the exposure of country i to country j based on trade linkages. The foreign variables $\boldsymbol{y}^*_{it}$ are assumed to be weakly exogenous with respect

[10] For notational simplicity, we present the model with the number of endogenous and foreign variables to be the same and homogeneous across countries. In the empirical implementation, these dimensions might vary. Also the common lag order is presented for convenience of processing of the coefficient matrices. It does not imply a restriction to the estimation of the model since the coefficient matrices can be filled with with zeros after country-wise estimation.

to the parameters of the VARX model in Equation (1.2). This assumption appears admissible given that N in our case is 39.

Summarizing the influence of global variables and deterministics in the vector $\boldsymbol{h}_{it} = \sum_{s=0}^{p} \boldsymbol{C}_{is}\boldsymbol{d}_{t-s} + \boldsymbol{\lambda}_i t + \boldsymbol{\mu}_i$ for notational simplicity, Equation (1.2) can be rewritten as

$$\boldsymbol{\Phi}_{i0}\boldsymbol{z}_{it} = \sum_{s=1}^{p} \boldsymbol{\Phi}_{is}\boldsymbol{z}_{it-s} + \boldsymbol{h}_{it} + \boldsymbol{\varepsilon}_{it}, \tag{1.4}$$

where $\boldsymbol{z}_{it} = (\boldsymbol{y'}_{it}, \boldsymbol{y'}^{*}_{it})'$, $\boldsymbol{\Phi}_{i0} = (\boldsymbol{I}_k, -\boldsymbol{B}_{i0})$, and $\boldsymbol{\Phi}_{is} = (\boldsymbol{A}_{is}, -\boldsymbol{B}_{is})$. Hence, $\boldsymbol{z}_{it}$ is linked to the endogenous variables $\boldsymbol{y}_t = (\boldsymbol{y}'_{1t}\ \boldsymbol{y}'_{2t}\ \dots\ \boldsymbol{y}'_{Nt})'$ through the link matrix $\boldsymbol{W}_i$ in the following way

$$\boldsymbol{z}_{it} = \boldsymbol{W}_i\boldsymbol{y}_t, \quad \boldsymbol{W}_i = \begin{pmatrix} \boldsymbol{0} & \dots & \boldsymbol{I}_k & \dots & \boldsymbol{0} \\ w_{i1}\boldsymbol{I}_k & \dots & w_{ii}\boldsymbol{I}_k & \dots & w_{iN}\boldsymbol{I}_k \end{pmatrix}. \tag{1.5}$$

Using this relation, Equation (1.4) is equivalent to

$$\boldsymbol{\Phi}_{i0}\boldsymbol{W}_i\boldsymbol{y}_t = \sum_{s=1}^{p} \boldsymbol{\Phi}_{is}\boldsymbol{W}_i\boldsymbol{y}_{t-s} + \boldsymbol{h}_{it} + \boldsymbol{\varepsilon}_{it}. \tag{1.6}$$

Stacking the individual country VARX models yields the following equation for y_t

$$\boldsymbol{G}_0\boldsymbol{y}_t = \sum_{s=1}^{p} \boldsymbol{G}_s\boldsymbol{y}_{t-s} + \boldsymbol{h}_t + \boldsymbol{\varepsilon}_t, \tag{1.7}$$

where

$$\boldsymbol{G}_0 = \begin{pmatrix} \boldsymbol{\Phi}_{10}\boldsymbol{W}_1 \\ \boldsymbol{\Phi}_{20}\boldsymbol{W}_2 \\ \dots \\ \boldsymbol{\Phi}_{N0}\boldsymbol{W}_N \end{pmatrix}, \boldsymbol{G}_s = \begin{pmatrix} \boldsymbol{\Phi}_{1s}\boldsymbol{W}_1 \\ \boldsymbol{\Phi}_{2s}\boldsymbol{W}_2 \\ \dots \\ \boldsymbol{\Phi}_{Ns}\boldsymbol{W}_N \end{pmatrix}, \boldsymbol{h}_t = \begin{pmatrix} \boldsymbol{h}_{1t} \\ \boldsymbol{h}_{2t} \\ \dots \\ \boldsymbol{h}_{Nt} \end{pmatrix}, \boldsymbol{\varepsilon}_t = \begin{pmatrix} \boldsymbol{\varepsilon}_{1t} \\ \boldsymbol{\varepsilon}_{2t} \\ \dots \\ \boldsymbol{\varepsilon}_{Nt} \end{pmatrix} \sim iid(0, \boldsymbol{\Sigma}_{\varepsilon}).$$

Equation (1.7) has to be pre-multiplied by $\boldsymbol{G}_0^{-1}$ to obtain the autoregressive representation of the GVAR model, the so-called global solution,

$$\boldsymbol{y}_t = \sum_{s=1}^{p} \boldsymbol{F}_s \boldsymbol{y}_{t-s} + \tilde{\boldsymbol{h}}_t + \boldsymbol{u}_t, \quad \boldsymbol{u}_t \sim iid(0, \boldsymbol{\Sigma}_u) \tag{1.8}$$

with $\boldsymbol{F}_s = \boldsymbol{G}_0^{-1}\boldsymbol{G}_s,\ s = 1, ..., p,\ \tilde{\boldsymbol{h}}_t = \boldsymbol{G}_0^{-1}\boldsymbol{h}_t$ and $\boldsymbol{u}_t = \boldsymbol{G}_0^{-1}\boldsymbol{\varepsilon}_t$ such that $\boldsymbol{\Sigma}_u = \boldsymbol{G}_0^{-1}\boldsymbol{\Sigma}_\varepsilon \boldsymbol{G}_0^{-1\prime}$. Estimates for the parameters of the global solution can be constructed based on the estimated individual-country VARX models. The global solution is equivalent to the reduced-form VAR representation of Equation (1.1), but with numerous within- and cross-equation restrictions. It can thus be used to perform standard VAR analysis and obtain structural impulse response functions (IRFs), as we do. In order to retain a parsimonious specification, the lag order p is set to one in the baseline case. The sensitivity analysis of our estimation results evaluates the implications of choosing higher lag orders.

1.3.3 Specification of the GVAR model

In specifying the underlying VARX models for the individual countries, we treat the U.S. equations differently than the EMEs equations. On the one hand, we include a different set of weakly exogenous variables, similar to what is commonly done in GVAR applications due to the dominant role of the U.S. in global financial markets (see, for instance, Eickmeier and Ng, 2015, Georgiadis, 2015a, or Chen et al., 2015). More importantly, as we are interested in an unconventional monetary policy shock, we set up a model that allows identifying such a shock.

Hence, the VARX model for the U.S. resembles VAR specifications from the literature on identifying conventional monetary policy shocks, usually containing output, inflation, and the Fed funds rate (see, among many others, Christiano et al., 1999). However, we replace the Fed funds rate as the monetary policy instrument by the size of the Fed balance sheet as in Gambacorta et al. (2014). Following the beginning of the financial crisis in 2008, the Federal funds rate soon reached its effective lower bound and stayed there for most of our sample period. Instead, the Fed introduced a number of (new) policy tools, most of which have altered both the size and the composition of its balance sheet, commonly referred to as unconventional monetary policy. The purpose of these tools has been to stabilize the functioning of financial markets, especially during the crisis, and to provide support to the economy during the recession and the subsequent sluggish recovery.

The balance sheet of the Fed more than quadrupled between 2007 and 2014 (see Figure 1.B.2 in Appendix 1.B). By using the size of the Federal Reserve balance sheet as the monetary policy instrument, the identified unconventional monetary policy shocks will be linked to all measures that increased the balance sheet. Notable policies that affected the balance sheet size start after the failure of Lehman Brothers in September 2008, as the Fed immediately provided credit to intermediaries and key markets. Other notable expansions are associated with the three programs of Quantitative Easing (QE) that were conducted. First, QE1, announced in November 2008 and expanded in March 2009, included purchases of mortgage backed securities and Treasury securities. In November 2010, it was succeeded by QE2 that focused on buying long-term Treasury securities. Lastly, QE3 was initiated in September 2012 and again included both mortgage backed securities and Treasury securities. Although these programs also affected the composition of the Fed balance sheet, the main change in the monetary policy stance was initiated through its expansion.[11] Hence, the size of the balance sheet should be a suitable instrument to measure the Fed's unconventional policy stance over our sample period.

Changes in the balance sheet size, however, do not only capture exogenous innovations to UMP, but also the endogenous reaction of the Fed to the state of the economy and, importantly, to financial market turmoil as e.g. in the immediate aftermath of the Lehman collapse. To identify an exogenous innovation to the balance sheet, we add the volatility index VIX to the model to capture financial market uncertainty. Lastly, we add total U.S. portfolio outflows as the variable of interest for our research questions. In sum, the following definition of endogenous and foreign

[11] In contrast, two unconventional monetary policy measures that did only alter the composition of the balance sheet are on the one hand the Fed's response to the run on Bear Stearns in March 2008, when it increased its lending to investment banks and other stressed financial intermediaries, but at the same time lowered its holding of short-term Treasury securities. On the other hand, between 2011 and 2012, the Fed ran a maturity extension program in which short- and medium-term Treasury securities were sold and proceeds used to purchase long-term Treasury securities to flatten the yield curve.

variables is used for the U.S. model:[12]

$$\boldsymbol{y}_{US,t} = (\text{output}, \text{inflation}, \text{VIX}, \text{Fed balance sheet}, \text{portfolio outflows})',$$
$$\boldsymbol{y}^*_{US,t} = (\text{foreign output}, \text{foreign inflation})',$$

where the balance sheet is included in its logarithm for the ease of interpretation. To distinguish between an exogenous innovation to the Fed balance sheet and an endogenous reaction of the central bank to the state of the economy or financial market turmoil, we follow Gambacorta et al. (2014) and impose a mixture of zero and sign restrictions on the structural impulse response functions. First, in accordance with standard assumptions in the literature, we assume that a shock to the policy instrument, in our case the Fed balance sheet, only has a lagged impact on output and inflation. The Fed itself reacts instantaneously to innovations to output and inflation as commonly assumed in VAR analysis of monetary policy transmission. Second, to account for the endogenous reaction to financial market turmoil, we use the sign restrictions displayed in Table 1.3.1. On the one hand, we assume that an expansionary UMP shock does not increase the VIX. This reflects the notion that UMP had the effect of mitigating concerns about financial instability. It is also in line with results by Bekaert et al. (2013) who show that an expansionary conventional monetary policy shock has a lowering effect on the VIX.[13] On the other hand, we define a shock that affects both the VIX and the Fed balance sheet in the same direction as a financial market risk shock to which the Fed responds, most notably seen in the immediate Lehman aftermath. The sign restrictions are imposed on impact and in the first month after the shock. Note that, as outlined in Section 1.2, the shock will primarily capture the actual implementation of UMP, namely measures that enlarge the balance sheet.[14]

[12] All models for the U.S. and for the EMEs include a constant and a linear time trend.

[13] In theory, it is also possible that unconventional monetary policy expansions increase the volatility by increasing the uncertainty about the future path of monetary policy or if the expansion is perceived as a harbinger of less encouraging prospects (compare Section 1.2). Fratzscher et al. (2016), however, show that, on average, press announcements by the Fed regarding unconventional monetary policy lowered the VIX on impact. Unfortunately, there is no comprehensive assessment of the impact of QE purchases on the VIX available, which is a subject potentially worth examining in future studies.

[14] Identifying the UMP shock using a Cholesky ordering and sign restrictions might pose a problem given the inclusion of financial variables, in this application most importantly U.S. portfolio outflows. Therefore, we have assessed the sensitivity of the results towards a different ordering of

Table 1.3.1: Sign restrictions to identify UMP shock

	Output	Inflation	VIX	Fed Balance Sheet
Unconv. Monetary Policy Shock	0	0	≤ 0	> 0
Financial Market Risk Shock	0	0	> 0	> 0

The table shows the sign and zero restrictions on the endogenous variables (columns) applied to identify the unconventional monetary policy shock and distinguish it from a financial market risk shock (rows).

The VARX specification for the EMEs is restricted by the rather short period of U.S. UMP. Given the limited number of observations, we cannot include all variables of interest into one large model. Instead, we consider two different models for different economic concepts of interest. First, we estimate a model which is focused on the response of real economic conditions to a U.S. UMP shock ("business cycle" (BC) model):

$$\boldsymbol{y}_{it} = (\text{output}, \text{real exchange rate change}, \text{portfolio inflows}, \text{real interest rate})',$$
$$\boldsymbol{y}^*_{it} = (\text{U.S. portfolio outflows}, \text{foreign output})'.$$

Second, we estimate a model to analyze the effect of a U.S. UMP shock on financial conditions in EMEs (FC model):

$$\boldsymbol{y}_{it} = (\text{portfolio inflows}, \text{real interest rate}, \text{real exchange rate change}, \text{equity returns})',$$
$$\boldsymbol{y}^*_{it} = (\text{U.S. portfolio outflows}, \text{foreign output})'.$$

The two models share the same VARX model for the U.S. to ensure that the UMP shock is the same across models. In the baseline specification, we include U.S. total portfolio outflows, the transmission channel of interest, and foreign output, as standard in the literature, as foreign variables $\boldsymbol{y}^*$ in the EMEs VARX models. Following Georgiadis (2015b), we include the potentially non-stationary level variables real GDP and real exchange rate in first difference form in all models.[15]

portfolio flows and using an identification strategy based on a shadow interest rate (see Section 1.4.3). Another approach would be to identify the VAR using external instruments as pioneered by Gertler and Karadi (2015) for conventional monetary policy. For a pure UMP shock and our sample, however, we did not find a valid instrument, most notably due to the zero lower bound.

[15] This has mainly two reasons. First, using differences ensures stability of the model across all different specifications. Estimating the different models in (log) levels using co-integrated global

1.3.4 Implementation of identifying restrictions

To implement the identifying restrictions in the GVAR, we proceed as follows. First, we estimate the model and retrieve its global solution given in Equation (1.8) that includes all endogenous variables across all countries. We then carry out a Cholesky decomposition of the covariance matrix of the residuals of the global model, $\boldsymbol{u}_t$, obtaining a lower triangular matrix $\boldsymbol{P}$. Multiplying this matrix with the corresponding moving-average coefficients of the global solution of the GVAR, $\boldsymbol{\Psi}_h$, $h = 0, 1, 2, ...$, yields the preliminary, standard orthogonalized IRF at horizon h, $\boldsymbol{\Psi}_h \boldsymbol{P}$. Since the effect of a shock identified from a Cholesky decomposition depends on the ordering of the variables, we implement the following concept-based scheme: we order the variables such that real GDP growth for the U.S. and all other countries (in the business cycle model) is followed by U.S. inflation and then, by the U.S. UMP variables (Fed balance sheet and VIX). These variables are then followed by all others, including interest rates, portfolio flows etc.[16]

The IRF obtained from this identification scheme does not yet satisfy the sign restrictions of Table 1.3.1 as the pure Cholesky scheme implies a recursive structure also in the contemporaneous relation between the VIX and the Fed balance sheet. In the next step, we multiply the preliminary IRF by an orthonormal rotation matrix $\boldsymbol{Q}(\theta)$ that takes the following form:

$$\boldsymbol{Q}(\theta) = \begin{pmatrix} \boldsymbol{I}_{m_1} & \boldsymbol{0}_{m_1,2} & \boldsymbol{0}_{m_1,m_2} \\ \boldsymbol{0}_{2,m_1} & \boldsymbol{Q}^{UMP}(\theta) & \boldsymbol{0}_{2,m_2} \\ \boldsymbol{0}_{m_2,m_1} & \boldsymbol{0}_{m_2,2} & \boldsymbol{I}_{m_2} \end{pmatrix}, \tag{1.9}$$

vector error-correction models (GVECMs) often yields explosive dynamics which makes a meaningful interpretation of the results difficult. Second, given our short sample period, estimations of the long-run relationship between the variables and, hence, the co-integration rank of GVECM have to be treated with caution. Therefore, for our application using a GVECM does not provide insurance against model mis-specification. Furthermore, all the variables are checked for stationarity in a panel unit root test, and are confirmed to be stationary. The results of the test are available in Appendix 1.D.

[16] The specific ordering of the variables after a shock does not have any consequence on their or other variables' responses to this shock.

where $\boldsymbol{Q}^{UMP}(\theta) = \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix}$.

$\boldsymbol{I}_r$ is an identity matrix of dimension $r \times r$, $\mathbf{0}_{r,s}$ is a zero matrix of dimension $r \times s$, and the corresponding dimensions are given by $(m_1, m_2) = (N+1, 2N-1)$ in the BC model and by $(m_1, m_2) = (2, 3N-2)$ in the FC model. The matrix $\boldsymbol{Q}(\theta)$ is thus set up in such a way that $\boldsymbol{Q}^{UMP}(\theta)$ affects the responses of the Fed balance sheet and the VIX to shocks to these two variables. The impulse response function for each θ is then given by $\text{IRF}(h) = \boldsymbol{\Psi}_h \boldsymbol{P} \boldsymbol{Q}(\theta)$. We draw rotation matrices $\boldsymbol{Q}(\theta)$ by drawing θ from a uniform distribution over the interval $[0, \pi]$ until we obtain the $\text{IRF}(h)$ that satisfies the sign restrictions in Table 1.3.1. The realized UMP shock is then given by the corresponding element in $\boldsymbol{\eta}_t = \boldsymbol{Q}'(\theta)\boldsymbol{P}^{-1}\boldsymbol{u}_t$ that raises the Fed balance sheet and, at the same time, does not increase the VIX.

In principle, there is a variety of models with different rotation matrices $\boldsymbol{Q}(\theta)$ that satisfy the sign restriction. We account for this fact by drawing rotation matrices $\boldsymbol{Q}(\theta)$ until we obtain 1000 admissible IRFs. Then, we apply the "median targeting" approach by Fry and Pagan (2007) and select among admissible models the one that yields IRFs that are closest to the median response across models and horizons. This approach has the advantage that the reported final IRFs are generated by one particular model and that the shocks are orthogonal. For statistical inference, we carry out 500 bootstrap replications of the same setup, with 1000 draws of the rotation matrix in each replication.

1.3.5 Evaluation of portfolio flows as a channel of shock transmission

Even if all the variables in the U.S. and in the EMEs, including portfolio flows, respond to the UMP shock identified above, this is not sufficient evidence that portfolio flows are indeed an important channel of shock transmission in line with Hypotheses 2b and 3b. In order to evaluate the role of portfolio flows in the transmission process, we document their quantitative contribution to the impulse responses of the EME variables by means of the following scenario analysis: given the estimated parameter matrices $\hat{\boldsymbol{G}}_s$, $s = 0, 1, ..., p$, we obtain corresponding matrices $\tilde{\boldsymbol{G}}_s$, $s = 0, 1, ..., p$, where the effects of all variables on both portfolio outflows from the U.S. and portfolio inflows into EMEs are counterfactually set to zero while all other effects are equal to their estimated values. The same scenario is applied to the estimated covariance matrix $\hat{\boldsymbol{\Sigma}}_\varepsilon$ such that we obtain a corresponding matrix $\tilde{\boldsymbol{\Sigma}}_\varepsilon$ where all covariances between the portfolio flow variables and all other variables are counterfactually set to zero while all other variances and covariances are equal to their estimated values.

Using these counterfactual effect matrices in the same algorithm as described in Section 1.3.4, we compute counterfactual impulse response functions $\widetilde{\text{IRF}}(h) = \tilde{\boldsymbol{\Psi}}_h \tilde{\boldsymbol{P}} \boldsymbol{Q}(\theta)$, where $\tilde{\boldsymbol{\Psi}}_h$ are the moving-average coefficients corresponding to $\tilde{\boldsymbol{F}}_s = \tilde{\boldsymbol{G}}_0^{-1} \tilde{\boldsymbol{G}}_s$, $s = 1, ..., p$, and $\tilde{\boldsymbol{P}}$ is the lower triangular Cholesky matrix to $\tilde{\boldsymbol{\Sigma}}_u = \tilde{\boldsymbol{G}}_0^{-1} \tilde{\boldsymbol{\Sigma}}_\varepsilon \tilde{\boldsymbol{G}}_0^{-1\prime}$. Comparing the resulting impulse response functions with the ones obtained from the estimated coefficients uncovers the part of the reaction of each variable that is generated through the responses of portfolio flows. Note that this scenario analysis should not be interpreted as representing alternative outcomes from a policy experiment, but simply as a summary statistic on the magnitudes of estimated coefficients. If the IRFs based on counterfactual matrices showed substantially smaller responses than the original ones, we would infer that portfolio flows constitute an important channel of transmission of U.S. UMP to EMEs' real and financial conditions and monetary policy in accordance with our Hypotheses 2b and 3b. Also note that the counterfactual exercise is conducted using the estimated parameter matrices and, thus, under the assumption of the estimated model being correctly specified.

1.4 Empirical results

In this section, we first present the main results regarding Hypotheses 1 to 3 that arise from the panel dimension of the sample. We also assess their sensitivity to various alterations of the model. Lastly, we analyze whether and how results from the panel dimension differ with respect to underlying country characteristics.

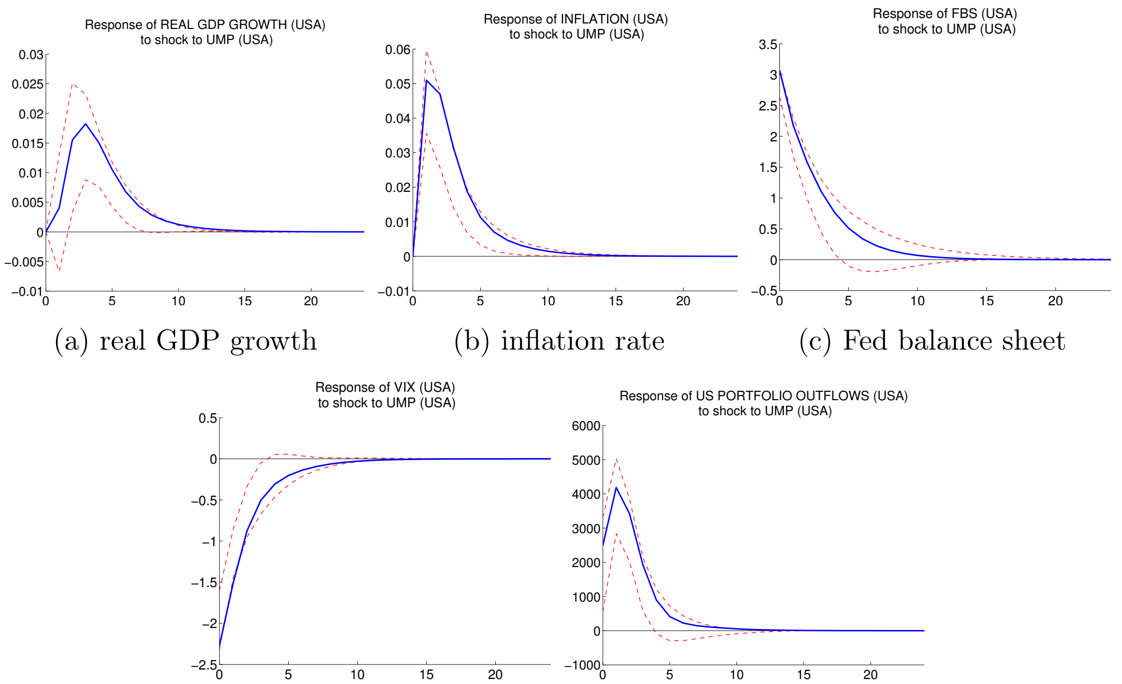
Before turning to the results, two facts regarding the estimated U.S. UMP shocks have to be noted that follow from a detailed examination of their time series representation (see Appendix 1.B). First, the identified balance sheet shocks capture the monetary policy stance of the Fed over the sample period well. The different phases of QE are, on average, associated with expansionary UMP shocks and ending the respective program of QE implies contractionary impulses (relative to the trend increase). Second, while shocks are overwhelmingly estimated to be positive for QE2 and QE3, this is not the case for QE1 as the increase in the balance sheet for QE1 has been less steep than for the other two programs. Hence, we will bear in mind that expansionary shocks in our specification are mainly associated with QE2 and QE3 when comparing our results to existing evidence on the individual programs.

1.4.1 U.S. reaction to UMP shock

We start by looking at the U.S. part of the estimated GVAR models for a first indication regarding Hypothesis 1 and assess if a UMP shock is related to an increase in capital outflows. IRFs for the U.S. variables to a one standard deviation expansionary UMP shock are depicted in Figure 1.4.1. Exemplarily, we present impulse response functions from the FC model. However, the reaction in the U.S. part of the model is virtually identical in the BC model. The standard deviation shock corresponds to an enlargement of the Fed balance sheet of roughly three percentage points (pp) on impact. As in all the following figures, the solid line represents the median response, and the red dotted lines represent bootstrapped 16% and 84% quantiles.

The response of real GDP growth is estimated to be significantly positive for a period of more than six months, reaching its peak after around four months at an increase of 0.02 pp. The response of inflation is similarly positive, peaks at a 0.05 pp increase, and remains significant for around five months. Moreover, the VIX is significantly reduced for four months after the UMP shocks while the balance sheet is significantly increased for around five months. These results are qualitatively very similar to the ones obtained by Gambacorta et al. (2014) in a comparable setting. However, the magnitude by which GDP and inflation respond is smaller which most likely reflects the larger parameter space of the GVAR. Finally, panel (e) of Figure 1.4.1 shows the response of U.S. portfolio outflows. Following a UMP shock, outflows increase immediately, reaching a peak at around four billion USD after two months. This finding is a first indication in favor of Hypothesis 1. Given how the estimated innovations relate to UMP measures (see above), this result is also in line with, for instance, Fratzscher et al. (2013), who find that QE2 triggered an immediate re-balancing of assets from the U.S into EMEs.[17]

Figure 1.4.1: Responses of U.S. variables to UMP shock



(a) real GDP growth (b) inflation rate (c) Fed balance sheet

(d) VIX (e) portfolio outflows

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the U.S. variables to the UMP shock in the financial conditions model. Confidence bands are based on 1000 bootstrap replications with 500 draws of the rotation matrix each.

1.4.2 EMEs' mean response to UMP shock

We then examine the average impulse responses of EMEs to the U.S. UMP shock in our two models, starting with the one capturing real economic conditions (see Figure 1.4.2).[18] As panel (a) shows, U.S. portfolio flows to EMEs increase significantly

[17] Our results show that the effect does not only appear on impact, but also entails a large degree of persistence as the UMP shock leads to a significant increase in portfolio outflows for almost half a year.

[18] The mean impulse response is calculated as the mean of the IRFs across all EME countries except Argentina. Argentina is included in the estimation, but it is excluded from the calculation of the mean because the estimated reaction of the real interest rate is implausibly large. Most likely, this is due to the data capturing the repeated debt restructuring and default that Argentina

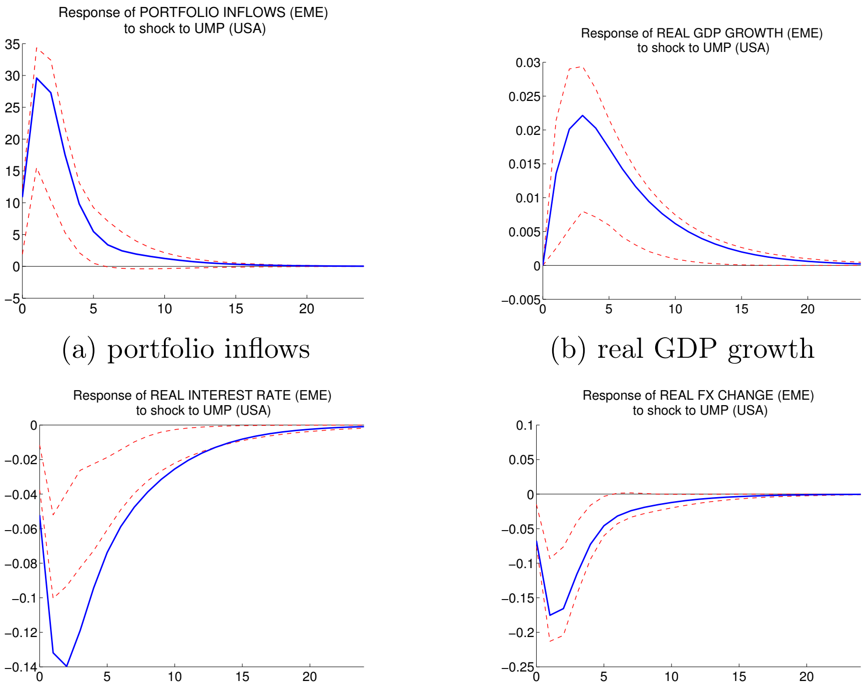
after a UMP shock, consistent with the increase in outflows found in the U.S. part of the model. Regarding the magnitude of the effect, however, the mean increase in inflows has its peak at around 30 million USD. Thus, around 600 million USD are estimated to flow into all EMEs, representing only about 15% of the total response of U.S. outflows. This finding is not necessarily surprising, as the data capture only flows going directly from the U.S. to EMEs. The data do not account for possibly substantial indirect flows from the U.S. to EMEs through subsidiaries of EME debtors residing in financial centers like the United Kingdom or Hong Kong, where the inflows are indeed estimated to be very large.[19] In this regard, results can be interpreted as a lower bound of actual portfolio inflows. In the model for financial conditions, portfolio flows are also found to increase, showing an almost identical reaction in shape and magnitude (see Figure 1.4.3). Taken together, these results provide support for Hypothesis 1.

The other variables in the business-cycle model are also found to respond significantly to a U.S. UMP shock. Real GDP growth in the EMEs increases by around 0.02 percentage points and stays above trend for almost one year. The short-term real interest rate, on average, decreases in response to the expansionary shock. This indicates pro-cyclicality in the monetary policy reaction as interest rates decrease while output increases, and that monetary policy is expansionary in response to an expansionary U.S. impulse, which can be interpreted as first support for Hypothesis 3a. Finally, the response of the real exchange rate shows that EMEs experience a real appreciation of the currency against the U.S. dollar after the UMP shock: the response peaks at an appreciation of around 0.17 pp and persists for roughly 5 months. Hence, one possible explanation for the decrease in the real interest rate is that monetary policy authorities to some extent try to deflect the inflows by lowering the policy rate, in an attempt to avoid an even larger appreciation.

experienced over the sample period, which was associated with strong movements in both nominal interest rates and inflation. The estimated IRFs for Argentina can be found in Figures 1.C.4 and 1.C.6 in Appendix 1.C. As outlined in Section 1.4.3, all our panel results are robust to dropping Argentina from the sample for the estimation of the model. Figures 1.C.5 and 1.C.7 in Appendix 1.C present the mean response including Argentina. Qualitatively and quantitatively, mean responses for the variables other than the real interest rate are very similar to those computed without Argentina.

[19] Figure 1.C.9 in Appendix 1.C show that portfolio inflows into the UK and Hong Kong alone amount to roughly 2.2 billion U.S. dollar during the first quarter after the shock.

Figure 1.4.2: Responses of EME variables to U.S. UMP shock in BC model



(a) portfolio inflows

(b) real GDP growth

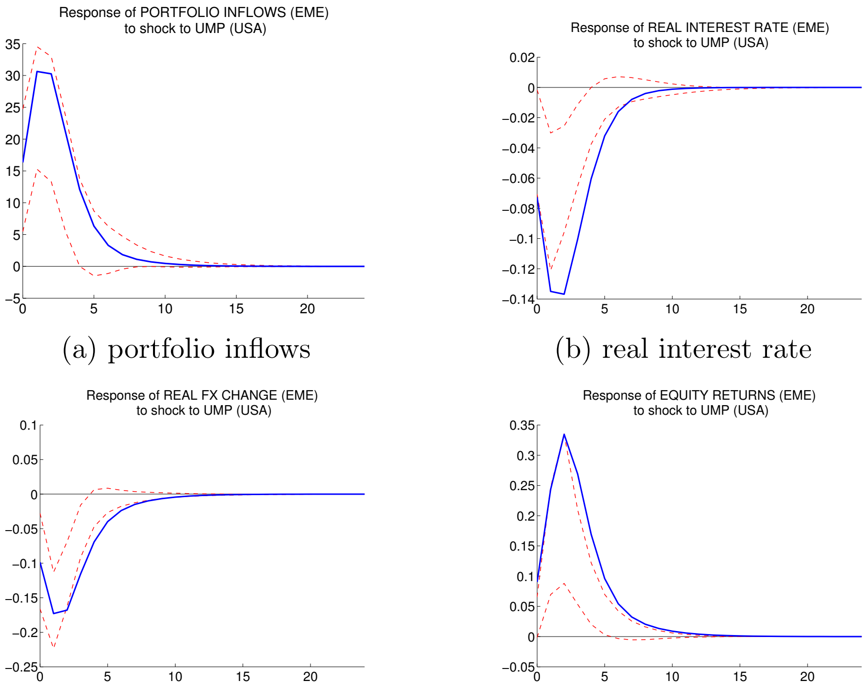
(c) real interest rate

(d) real fx change

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the business cycle (BC) model. Confidence bands are based on 1000 bootstrap replications with 500 draws of the rotation matrix each.

Turning to EMEs financial conditions, Figure 1.4.3 shows the results for the model that includes the responses of portfolio inflows, real exchange rates, real interest rates, and equity returns to an expansionary U.S. UMP shock. Following the shock, portfolio inflows increase in the same magnitude as in the model for the business cycle. Similarly, both the real exchange rate and real interest rate response closely mirror the responses of these variables in the business cycle model. The surge in inflows, the real appreciation, and the lower interest rate are accompanied by a significant increase in equity returns, which lasts for around five months. Hence, these responses suggest that financial conditions, proxied by the exchange rate and equity returns, are indeed affected by an expansionary UMP shock in the U.S., thus providing support for Hypothesis 2a.

Figure 1.4.3: Responses of EME variables to U.S. UMP shock in FC model



(a) portfolio inflows

(b) real interest rate

(c) real fx change

(d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 1000 bootstrap replications with 500 draws of the rotation matrix each.

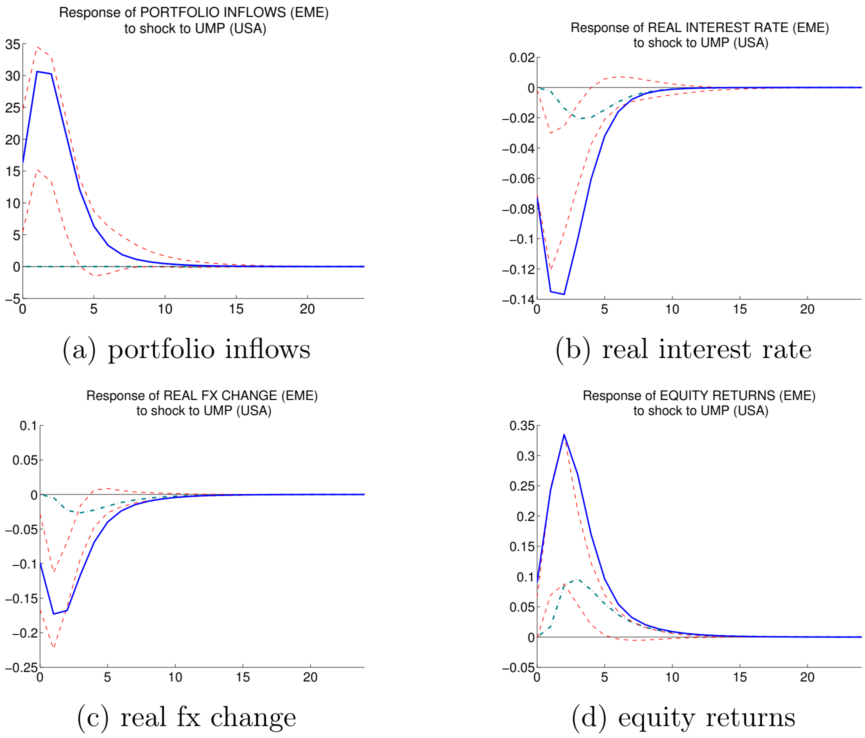
Next, we evaluate the role of portfolio flows as an important channel of shock transmission as implied by Hypotheses 2b and 3b. So far, we have presented results from empirical models where portfolio outflows and foreign output are the transmission channels of U.S. shocks in the GVAR specifications (compare Section 1.3.3). For a first indication on the importance of capital flows in the transmission, we re-estimate the FC model with various alterations regarding the transmission vector $\boldsymbol{y}^*_{it}$ for the EMEs. The results of this exercise can be found in Appendix 1.C. First, we drop foreign output from $\boldsymbol{y}^*_{it}$. Doing this leaves the IRFs qualitatively and quantitatively almost unchanged compared to the baseline specification, suggesting that foreign output is not the primary transmission channel that drives the results for financial conditions (see Figure 1.C.8 in Appendix 1.C). On the other hand, if we use only foreign output as a transmission channel in $\boldsymbol{y}^*_{it}$, spillovers from U.S. policy shocks are estimated to be considerably smaller. We also add other financial variables to capital flows in $\boldsymbol{y}^*_{it}$ (foreign interest rates, foreign lending rates and foreign equity returns), replacing foreign output one-by-one, to check whether this alters our main results. For the first two alternative specifications, we find that results are qualitatively and also quantitatively similar to the baseline model, suggesting that transmission is already captured by capital flows. Only the inclusion of foreign equity returns produces larger total spillovers from UMP shocks.

This underlines the importance of financial markets in transmitting monetary policy shocks and highlights that portfolio flows are not the only channel of transmission. Overall, the results from the different specifications regarding $\boldsymbol{y}^*_{it}$ are first support for Hypotheses 2b and 3b: capital flows are an important channel of transmission of U.S. UMP shocks.

To further investigate this hypothesis, we present a counterfactual exercise from our main specification of model FC where the transmission through capital flows is artificially turned off after estimation (compare Section 1.3.5). In particular, we set all coefficients that load on U.S. portfolio outflows or on EME portfolio inflows to zero, leaving all other coefficients at their estimated values. This exercise should not be interpreted as a policy experiment (e.g. the implementation of capital account restrictions), but simply as a summary statistic on the magnitude of the effects through portfolio flows within the estimated model. Also note that the counterfactual does not aim at isolating the effect going through one of the channels of transmission outlined in Section 2, but captures the overall importance of portfolio flows for the reaction of the variables in the GVAR to the UMP shock. The resulting IRFs from this exercise for the EMEs are presented in Figure 1.4.4. They show that responses of real interest rates, real exchange rate changes and equity returns are substantially smaller compared to the baseline IRFs and thus, underline the quantitative importance of portfolio flows for the transmission of the UMP shock to EMEs.[20] In sum, we interpret the results from this section as providing strong evidence in favor of our Hypothesis 2a and 2b, that U.S. UMP drives financial conditions in EMEs, and that portfolio flows are an important channel of transmission.

[20] Feedback effects through portfolio flows to the U.S. economy seem to be small, such that the IRFs for U.S. variables to the UMP shock are basically unaffected, see Figure 1.C.11 in Appendix 1.C.

Figure 1.4.4: Counterfactual responses of EME variables to U.S. UMP shock



(a) portfolio inflows (b) real interest rate (c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses (blue solid line) and the 68 percent confidence bands (red dashed line) of the EME variables to the UMP shock in the financial conditions (FC) model along with the mean responses in the same model where the transmission through capital flows is counterfactually turned off (green dash-dotted line).

1.4.3 Sensitivity to alternative specifications

Next, we evaluate the sensitivity of the results from the panel dimension to changes in the specification of the model.[21] We start by assessing the sensitivity of the results to the ordering of variables in the identification scheme. Instead of the concept-based ordering implemented in the baseline specification, we choose a country-based ordering, where the U.S. are placed first. Within the U.S. part of the model, the variables follow the ordering as specified in Section 1.3.3, i.e. output and inflation are followed by the UMP variables, the VIX and the Fed balance sheet. All other variables of the model follow accordingly. This scheme features a stronger isolation of the U.S. from the rest of the world since U.S. monetary policy does not react to

[21]IRF graphs from this subsection are available in Appendix 1.C.

any contemporaneous innovations abroad. The qualitative results are robust to this change in ordering. Another alternative ordering scheme that we apply focuses on the timing of portfolio flows. In particular, different to the baseline specification, we try an ordering scheme where all capital flow variables in the model are placed in front of the UMP block. This is done to allow for U.S. monetary policy to react instantaneously to portfolio outflows. On the other hand, this alternative ordering implies that the immediate response of portfolio flows to the UMP shock is zero. Despite the difference in the impact reaction, the overall response of U.S. portfolio outflows and EME portfolio inflows is still very similar to the baseline specification. This holds qualitatively and quantitatively.

Returning to our baseline ordering, we perform a number of additional robustness checks. For instance, we drop several countries one-by-one from the sample that display large reactions in one or more variables and find that mean responses change slightly quantitatively, but not qualitatively. We also perform the estimation using only a post-Lehman sample, i.e. starting in November 2008 instead of January 2008, and find no large qualitative changes resulting from this alteration. Likewise, in the baseline estimation we parsimoniously only include one lag in each country-specific VARX model. As a robustness exercise, we allow for a second or a third lag in the country-specific VARX models based on information criteria. Our findings are very robust to this exercise. A further robustness analysis is to include commodity price inflation as an exogenous (global) variable given that commodity price developments potentially play an important role for several EMEs. The results are qualitatively similar, but the inclusion of this exogenous variable produces smaller - but still significant - reactions of the the EMEs' variables, except for portfolio inflows, which stay almost unchanged.

We also assess whether only one kind of portfolio assets, equity assets or bonds, drives the reaction of flows after a UMP shock. To do so, we replace the portfolio flow variables in our baseline model with equity flows and bond flows, respectively. We find that both equity and bond inflows into EMEs increase, with the rise in bond flows being larger on average. Also, from a cross-country comparison no obvious pattern arises which would indicate the relative importance of one type of flows over the other for single countries.

Further, to assess our identification strategy, we investigate how other U.S. variables react to the UMP shocks in our model and compare the results to evidence from the literature. As found by Wright (2012) and Rogers et al. (2014), U.S. UMP causes a depreciation of the dollar and an increase in U.S. equity prices, among others. Hence, we add those variables separately to the U.S. part of the model and study the estimated response functions. Both responses look as expected given existing evidence, but do not affect the responses of the baseline variables, and thus provide further support for our identification strategy.

As an alternative (unconventional) monetary policy instrument to identify the structural UMP shocks, we use the shadow federal funds rate constructed by Wu and Xia (2016). Specifically, we replace the UMP block, namely the VIX and the balance sheet, in our baseline model with the shadow rate and then apply a recursive ordering scheme to identify the UMP shock. Doing this yields qualitative similar responses for the EME variables as our baseline model with the identification scheme based on Gambacorta et al. (2014).

Lastly, we replace our preferred measures of financial conditions from the main specification one-by-one by other proxies that potentially similarly capture financial developments, and assess whether the reaction of the other variables is robust to this alterations. First, in the model FC, we replace the real interest rate, our proxy for domestic monetary policy, by the real lending rate. The responses of capital inflows, the real exchange rate and equity returns remain unaffected compared to the baseline FC model. The lending rate, on the other hand, displays a reaction very similar to the response of the interest rate in our baseline model, reflecting a close connection of the two rates in our sample. Second, following Bowman et al. (2015), we replace the real interest rate in the model FC by the long-term government bond yield. As before, we find that the reaction of flows, exchange rates, and equity prices is robust to this alteration. The mean responses show that long-term government bond yields significantly decrease, in line with findings by Bowman et al. (2015).

Third, we re-estimate the model FC replacing the interest rate by foreign exchange reserves growth. We do so as the accumulation of reserves is a policy tool actively used by central banks in EMEs, for instance to alleviate exchange rate appreciation pressures. Again we find that the reaction of portfolio flows, equity returns, and exchange rates is robust to this alteration. Moreover, reserve accumulation increases in response to the UMP shock. Similar to the real interest rate response in the baseline model, this indicates that monetary policy in EMEs reacts to the U.S. expansion. In particular, the increase in reserves could be related to policies aimed at mitigating a currency appreciation that arises from the capital inflows.

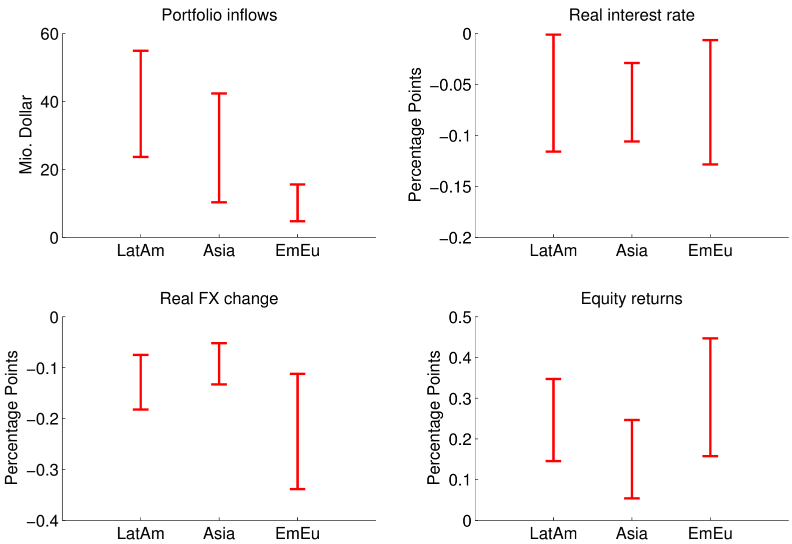
1.4.4 The role of economic characteristics of countries

Finally, we go into detail and analyze if and to what extent EMEs are affected differently by the U.S. UMP shock. For this purpose, we split our sample of countries in different ways according to economic characteristics and analyze whether the responses of portfolio flows, domestic financial conditions, and monetary policy rates to the shock differ between groups. In particular, we look at differences in the estimated peak responses of the variables from model FC across groups with different country characteristics. The differences in peak responses correspond very closely to the differences in cumulated IRFs for the country groups.

First, we consider the role of country geography. U.S. capital flows towards Europe, for instance, may not be as large as towards Latin America, since the latter has tighter economic and geographical linkages to the U.S. The EMEs we analyze are grouped by geographic region as follows: Latin America (Brazil, Chile, Colombia, Mexico, Peru), Europe (Hungary, Poland, Russia, Turkey) and Asia (India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand). 68% confidence bands of estimated peak effects in response to the U.S. UMP shock for the different regions are displayed in Figure 1.4.5. The full set of responses are depicted in Figures 1.C.1 – 1.C.3 in Appendix 1.C.

We indeed observe the strongest reaction of capital inflows after an expansionary shock for Latin American countries, whereas the smallest reaction is found for European countries. In principle, comparisons of total flows have to be treated with caution as they do not take into account that groups may vary by economic size. The group of Latin American countries and the group of European countries, however, are of similar size regarding their total GDP, while GDP of the Asian countries is even larger. The larger response of portfolio flows to Latin America compared to Asia is reflected in slightly stronger responses of equity returns and exchange rates. On the other hand, European interest rates and equity returns react with similar magnitude as their American counterparts whereas the foreign exchange reaction is even more pronounced. This can be explained by effects being enhanced by close trade linkages to advanced European countries, and in particular by currencies being tied to the euro. In sum, there is evidence for limited regional heterogeneity in quantitative respect, indicating that the capital flow channel is of particular importance for Latin America, whereas for Asia and Emerging Europe also other channels play an important role. Qualitatively, however, responses across regions are very similar.

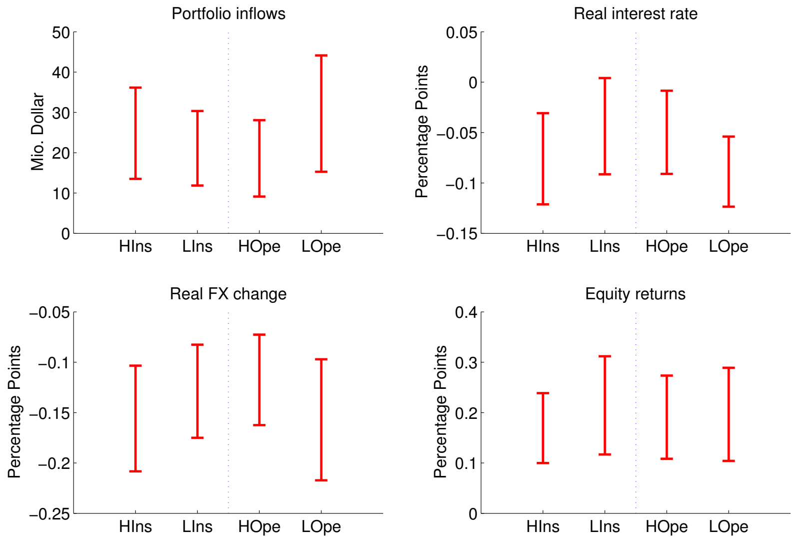
Figure 1.4.5: Peak responses across geographic regions



Note: The figure shows 68 percent confidence bands of estimated peak effects for the model FC across different geographical regions. LatAm: Latin America, EmEu: Emerging Europe.

Next, we study the role of institutional quality, as Fratzscher et al. (2013) find evidence that countries with better institutions are less affected by Fed policies. We follow their approach and proxy the institutional quality by the 2007 average of the following four indicators of governance: 'Political Stability', 'Rule of Law', 'Control of Corruption' and 'Regulatory Quality'; all from Kaufmann et al. (2010). The country characteristics are predetermined to account for the possibility that they might be contemporaneously related to U.S. UMP. Then, we split our sample into two groups, one with institutional quality above the cross-country median and one with institutional quality below the cross-country median. Figure 1.4.6 (left half of each graph) shows that peak responses are very similar for both groups of countries. Hence, we do not find evidence that the EMEs in our sample are affected differently due to differences in institutional quality. The difference to the results by Fratzscher et al. (2013) can be explained by the fact that their sample also contains advanced economies, who – on average – have a higher institutional quality than EMEs.

Figure 1.4.6: Peak responses across country groups with different degree of institutional quality / openness



Note: The figure shows 68 percent confidence bands of estimated peak effects for the model FC across country groups with different characteristics. HIns: institutional quality above cross-country median, LIns: institutional quality below cross-country median, HOpe: financial openness above cross-country median, LOpe: financial openness below cross-country median.

We also analyze whether countries with a lower degree of financial openness are better insulated from U.S. UMP shocks. Financial openness is proxied by the Chinn-Ito coefficient for capital account openness (Chinn and Ito, 2006). Again, we use the 2007 value of the country characteristic to avoid problems of endogeneity and split our sample into two groups, one with financial openness above the median and one with openness below. Peak responses for the two groups are displayed in Figure 1.4.6 (right half of each graph). There is no evidence that countries with a higher degree of financial openness at the start of our sample are more strongly affected by the UMP shock.[22]

[22] It is important to keep in mind that this result cannot be interpreted as a test of how efficient the countries' micro- and macroprudential measures were during and after the crisis. As the introduction of measures like capital controls is highly endogenous to the degree of capital inflows following a monetary policy shock, this question cannot be addressed in the current framework and constitutes an important avenue for future research.

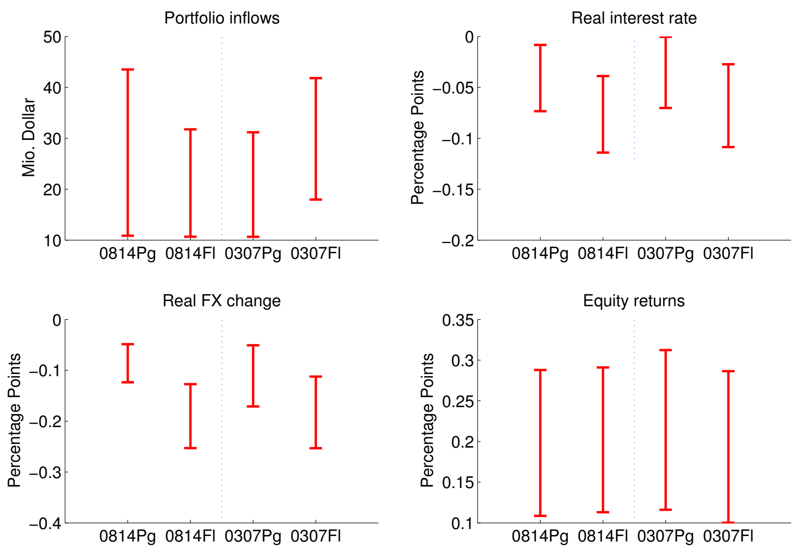
Finally, we study how responses to the UMP shock differ with respect to the countries' exchange rate arrangements. This is motivated by the classical "trilemma", which states that countries can only have two of the following three policy options: independent monetary policy, free capital flows, or a fixed exchange rate. Hence, countries that let their currency float freely might have potentially more leeway for an independent monetary policy, meaning that they can set interest rates independently of the U.S. and, in turn, achieve a better buffering of U.S. shocks. Empirical studies often find evidence for this kind of reasoning (see Klein and Shambaugh, 2015, or Aizenman et al., 2016). However, Rey (2013) argues that the trilemma is often reduced to a dilemma: a floating exchange rate regime alone might not be sufficient to insulate countries from the global financial cycle and U.S. monetary policy as one of its drivers.

Ideally, we would thus split our sample countries in those that are situated in a floating exchange rate regime ("floaters") and those that fix there exchange rate ("peggers"). This, however, is not a straightforward task given our sample period in which most of the countries are *de jure* considered to be floaters. Therefore, we turn to Klein and Shambaugh (2008)'s *de facto* classification of countries' prevailing exchange rate regimes for this task, which is based on observable exchange rate variation and is commonly used in the literature. Following the strategy outlined above, we split our sample into two groups, one with exchange rate flexibility above the cross-country median and one with exchange rate flexibility below the cross-country median. We measure exchange rate flexibility in two ways, namely by the number of years that a country was considered a floater in the years 2003–2007 and 2008–2014, respectively. While the latter classification potentially suffers from an endogeneity bias between exchange rate stability and the amount of capital inflows, it serves as a useful benchmark for the results based on pre-crisis data. Both classifications yield similar, but slightly different groups of countries.[23]

[23]Different to the other country characteristics, we do not only use one year of data to group the countries since *de facto* exchange rate classifications are far less persistent than the degree of institutional quality of financial openness considered above. The classification of Klein and Shambaugh (2008) can be found on Jay C. Shambaugh's homepage. As alternative specifications we have also classified countries using only their 2007 observations, which yielded qualitatively similar results. As an alternative dataset, we have used the coarse classification by Reinhart and Rogoff (2004) and applied a similar classification strategy. The resulting groups are slightly different, but the results regarding the responses to the policy shock in both country groups are very similar.

Figure 1.4.7 shows the peak responses for the variables in model FC for the group of floaters (above median) and the group of peggers (below median) for both classifications. It indicates that, despite small changes in the group compositions, results between the two classifications are very similar. Both floaters and peggers receive capital inflows of similar magnitude and also experience a similar increase in asset prices. Moreover, currencies in both groups are found to appreciate after the shock, reflecting the fact that the group of peggers does not constitute hard pegs in our sample. Not surprisingly, the appreciation is stronger in countries that float freely. Of particular interest in the sense of the trilemma is the reaction of monetary policy in both groups as floating countries should experience a higher degree of policy independence and thus, should display less of a mirroring interest rate reaction to the expansionary U.S. shock. However, we find that both groups react to the expansionary shock by decreasing their own monetary policy rates, indicating a procyclical reaction of monetary policy as found in the panel results.

Figure 1.4.7: Peak responses across country groups with different exchange rate flexibility



Note: The figure shows 68 percent confidence bands of estimated peak effects for the model FC across country groups with different degrees of *de facto* exchange rate flexibility. 0814Pg: flexibility in 2008–2014 below cross-country median, 0814Fl: flexibility in 2008–2014 above cross-country median, 0307Pg: flexibility in 2003–2007 below cross-country median, 0307Fl: flexibility in 2003–2007 above cross-country median.

Together with the evidence obtained in Section 1.4.2 (Figure 1.4.4 panel b) on the importance of portfolio flows as a transmission channel for the UMP shock, we interpret this result as strongly supporting our Hypothesis 3: via portfolio flows, U.S. UMP significantly influences monetary policy in EMEs.

Furthermore, our results imply that a floating exchange rate regime alone is not sufficient to insulate the EMEs in our model from the U.S. UMP shock. This is in line with the findings of Passari and Rey (2015) and Rey (2016) for a group of small open advanced economies and U.S. interest rate surprises. However, our results are not necessarily at odds with existing evidence that stresses the importance of exchange rate regimes and the classical trilemma. These studies often cover a broader range of shocks, countries as well as time periods, and allow for a more detailed analysis on how the varying degrees of exchange rate flexibility and also capital control intensity are related to the reaction of domestic monetary policy.

There are a number of caveats to the analysis offered in this subsection that need to be mentioned. Our results most likely constitute lower bounds for the capital inflows into EMEs after a UMP shock as they do not take the issuance of debt through subsidiaries into financial centers into account (compare Section 1.3.1). The likelihood that corporations in a country issue debt through an offshore subsidiary could be related to the underlying country characteristics, in particular the exchange rate regime or the degree of financial openness. Should this be the case, results for the individual groups could differ if it would be possible to account for offshore subsidiaries. Moreover, it is important to note that the different country characteristics might not be independent from each other. Lastly, due to a lack of data availability, the influence of other micro- and macroprudential measures that were taken during the crisis is not taken into account. Nevertheless, overall our results are indicative that neither a floating exchange rate nor a higher degree of institutional quality or a lower degree of financial openness are sufficient to insulate countries from the spillovers of U.S. UMP.

1.5 Conclusion

In this paper, we investigated empirically whether U.S. unconventional monetary policy has an impact on financial and real variables in emerging market economies, and examined whether portfolio flows are an important channel of transmission. In contrast to existing studies, we used a structural global vector autoregressive approach that takes economic interlinkages between countries and across time into account and allows to assess the persistence of the effects of U.S. UMP shocks.

We found that an expansionary UMP shock significantly increases portfolio outflows from the U.S. for almost six months. In the EMEs, this is equivalently associated with portfolio inflows. Along with the increase in inflows, real output growth and equity returns rise, the real exchange rate appreciates and the real lending rate decreases. Importantly, portfolio flows proved to be an important channel of transmission in the GVAR specification. We also found that EMEs, on average, react pro-cyclically by decreasing their short-term interest rate in response to the U.S. shock, indicating a monetary policy response that mirrors the expansionary U.S. impulse. All our findings appeared to be independent of economic characteristics like the degree of financial openness, institutional quality, or the underlying exchange rate regime of a country.

Our results complement existing evidence along different dimensions. Fratzscher et al. (2013), for instance, found that UMP in the U.S. had a direct effect on portfolio reallocation between advanced economies and EMEs. We showed that U.S. shocks have persistent effects on portfolio flows, and that these flows are a channel of transmission to EMEs. Miranda-Agrippino and Rey (2015) found that U.S. monetary policy had an effect on financial conditions worldwide for the period 1980–2010. We obtained a comparable result for the particular period of unconventional monetary policy. Lastly, Passari and Rey (2015) and Rey (2016) showed for a group of open advanced economies that countries with a flexible exchange rate regime are not insulated from U.S. monetary policy. We documented that also EMEs with a flexible exchange rate arrangement are affected by U.S. UMP shocks.

Finally, some limitations of our analysis are particularly interesting for future research. Given our identification strategy and sample period, we did not analyze the effects of uncertainty about the end of UMP in the U.S. (for instance, the so-called "taper tantrum"). Future research might explore how such policy uncertainty affects portfolio flows between the U.S. and EMEs. Furthermore, the dataset on capital flows does not take potential flows through subsidiaries in financial centers into account. It might be interesting to study in future research whether the likelihood of issuing bond and equity assets by EME firms through offshore subsidiaries is related to cross-country characteristics, like the degree of financial openness or the exchange rate regime.

Appendix

1.A Data and sources

Table 1.A.1: Data construction and sources

Variable	Construction and source
Inflation	First difference of log of monthly consumer price index (CPI), in percent. Source: Datastream (U.S.: St. Louis FRED).
Equity return	First difference of log MSCI equity, in percent. Source: Datastream (U.S. CPI: St. Louis FRED).
Real output	Monthly real GDP is obtained by interpolating quarterly log real GDP with log index of industrial production using the method of Chow and Lin (1971). Real GDP growth is first difference of log real GDP, in percent. Source: Datastream (U.S.: St. Louis FRED).
Fed balance sheet	Sum of assets held by Federal Reserve System. Source: St. Louis FRED.
VIX	Option-implied volatility index. Source: Chicago Board Options Exchange, retrieved from St. Louis FRED.
Real exchange rate	Calculated from log nominal U.S. dollar exchange rate e_t using the following formula: $e_t + \ln \mathrm{CPI}_t^{US} - \ln \mathrm{CPI}_t$. Real exchange rate change is first difference of log real exchange rate, in percent. Source: Datastream (U.S. CPI: St. Louis FRED).
Real interest rate	Calculated from nominal short-term interest rate i_t using the following formula: $i_t - 12 \cdot \Delta \ln \mathrm{CPI}_t \cdot 100$. As nominal short-term rate, we choose the monetary policy rate (exact definition depends on policy measures of the respective country ("target rate", "policy rate", ...). Source: Datastream (U.S. CPI: St. Louis FRED).
Real lending rate	Calculated from nominal lending rate l_t using the following formula: $l_t - 12 \cdot \Delta \ln \mathrm{CPI}_t \cdot 100$. Source: IMF International Financial Statistics (IFS), (U.S. CPI: St. Louis FRED).
Real effective exchange rate	Log of index of real effective exchange rate. Change is first difference, in percent. Source: Bank of International Settlements, retrieved from Datastream.

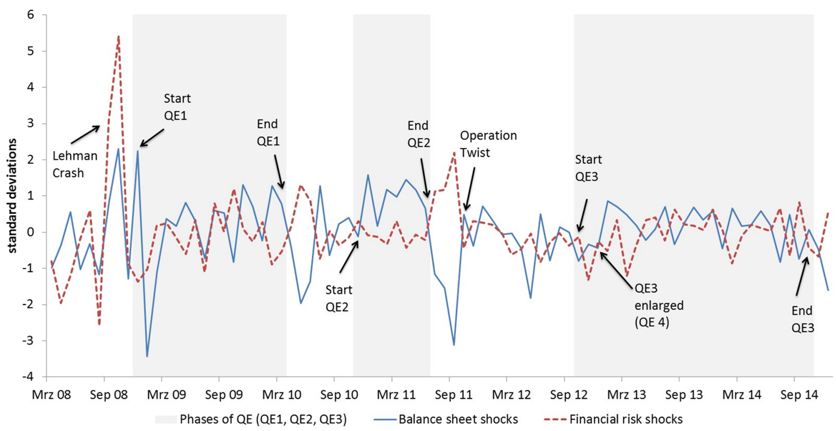
Foreign exchange reserves	First difference of log foreign exchange reserves, in percent. Source: IFS.
Government bond yield	Source: Datastream.
Commodity price inflation	First difference of log commodity price index, in percent. Source: IFS.

1.B Identified exogenous balance sheet innovations

For a better interpretation of the identified U.S. UMP shocks, we examine their time series representation. This inspection allows us to assess whether the major policy measures taken by the Fed during and after the financial crisis (see Section 3.3 in the paper) are reflected in the estimated innovations. Given that most of the measures have to some extent an unexpected component, this is a useful check of the identification approach. In doing so, we follow Boeckx et al. (2014) who apply a similar balance sheet driven identification strategy for UMP by the ECB.

Figure 1.B.1 shows the time series of the identified UMP innovations in the balance sheet as well as the time series of identified financial market risk shocks. The phases of Quantitative Easing (QE) are depicted as shaded areas.[24] The sum of the shocks is, by construction as a white noise residual, zero over the sample period and the scale is standard deviations. A positive shock reflects an expansionary shock while a negative impulse is associated with a tightening of the balance sheet relative to the average endogenous response to other shocks hitting the economy.

Figure 1.B.1: Time series of balance sheet shocks and financial market risk shocks



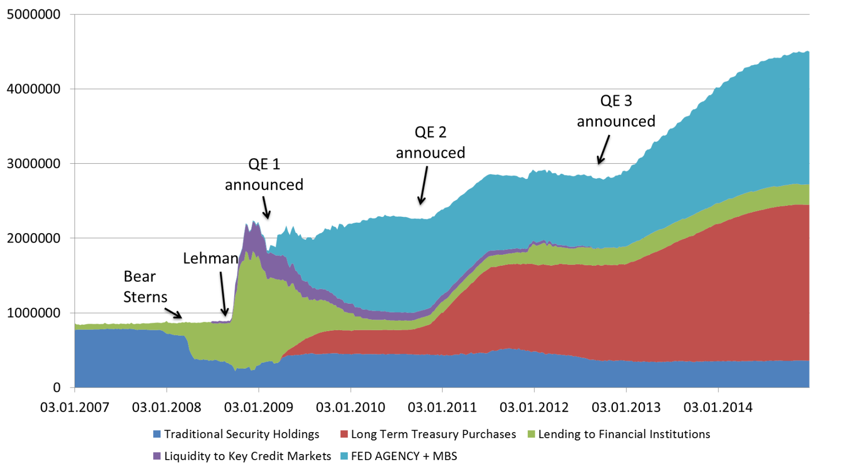
Note: The figure shows the estimated unconventional monetary policy shock, reflecting an unexpected extension of the balance sheet, and financial market risk shock, capturing financial market turbulence to which the Fed responds, as well as phases of quantitative easing (shaded areas) and important monetary policy decisions over the sample period. The scale is standard deviations.

[24]The shock series shown in the figure correspond to the model that yields the median IRF in the baseline specification with equity prices, i.e. the financial conditions model. The shocks, however, are virtually identical for the two specifications.

The figure shows that the identified balance sheet shocks capture the monetary policy stance of the Fed over the sample period well. The different phases of QE are, on average, associated with expansionary UMP shocks. On the other hand, ending the respective program of QE implies contractionary impulses. This is in line with the notion that the first two programs were ended despite no major improvement in economic conditions and financial stability. Nevertheless, there are differences between the identified UMP shocks over the different phases of QE. While shocks are overwhelmingly estimated to be positive for QE2 and QE3 (after its enlargement in December 2012), this is not the case for QE1. The main reasons for this is that the increase in the balance sheet for QE1 has been less steep than for the other two programs (see Figure 1.B.2). Hence, the estimated policy reaction function in the GVAR, which also includes a linear trend, perceives QE1 as less expansionary than QE2 and QE3. This result has to be borne in mind when comparing our results to existing evidence on the individual programs.

The financial market risk shock, in contrast, most notably captures the turmoil associated with the collapse of Lehman Brothers in 2008. Hence, most of the Fed balance sheet enlargement directly after Lehman is regarded by the model as an endogenous reaction to the collapse and not an exogenous policy innovation. This reflects the identification strategy which exactly aims at disentangling an endogenous reaction to financial market turmoil from expansionary policy.

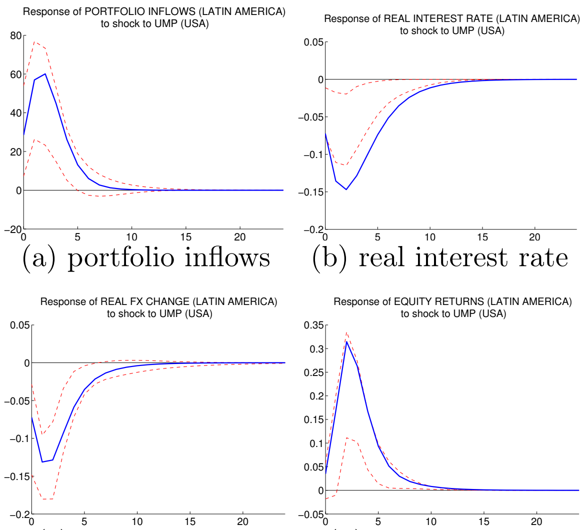
Figure 1.B.2: Federal Reserve assets by type, 2007–2014



Note: In Million of U.S. dollars. Source: Federal Reserve Bank of Cleveland

1.C Additional figures

Figure 1.C.1: Responses of Latin America's variables to U.S. UMP shock – model: FC

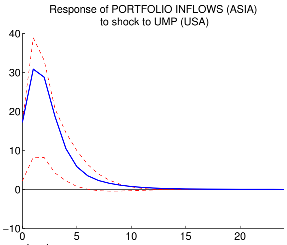


(a) portfolio inflows (b) real interest rate

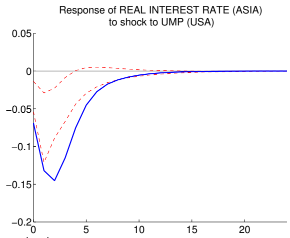
(c) real fx change (d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the FC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

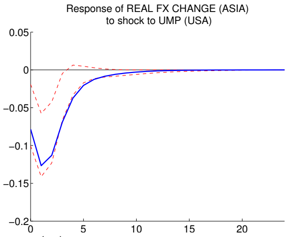
Figure 1.C.2: Responses of Asia's variables to U.S. UMP shock – model: FC



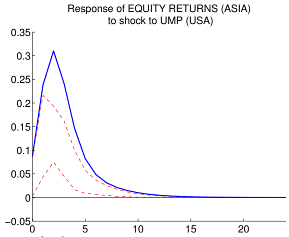
(a) portfolio inflows



(b) real interest rate



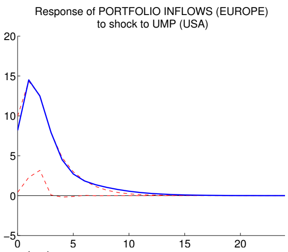
(c) real fx change



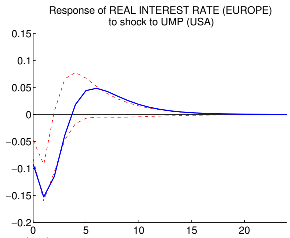
(d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the FC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

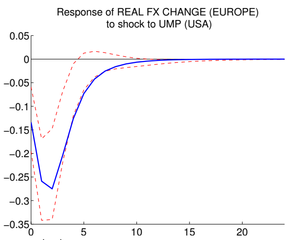
Figure 1.C.3: Responses of Europe's variables to U.S. UMP shock – model: FC



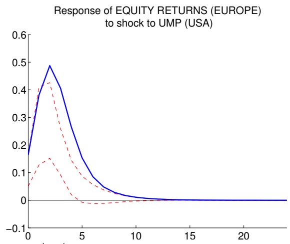
(a) portfolio inflows



(b) real interest rate



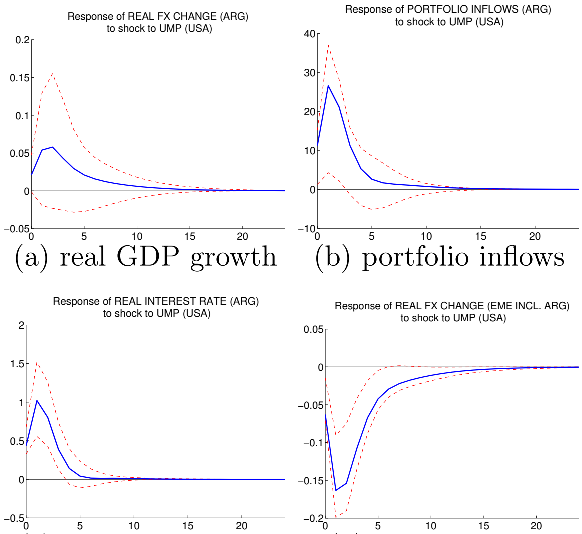
(c) real fx change



(d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the FC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.4: Responses of Argentina's variables to U.S. UMP shock – model: BC

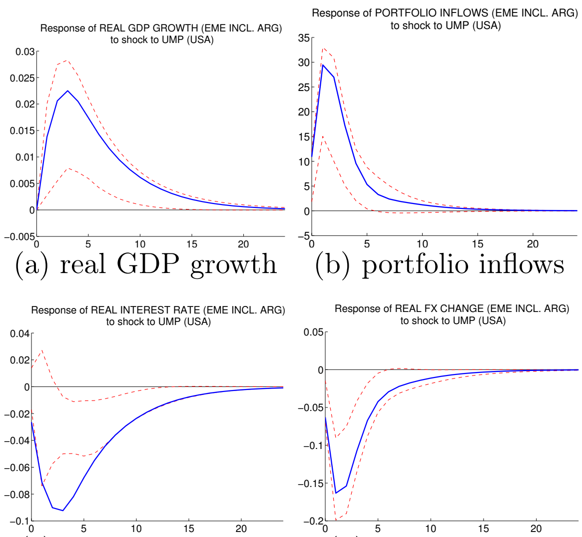


(a) real GDP growth (b) portfolio inflows

(c) real interest rate (d) real fx change

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the BC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.5: Responses of EME variables (mean including Argentina) to U.S. UMP shock – model: BC

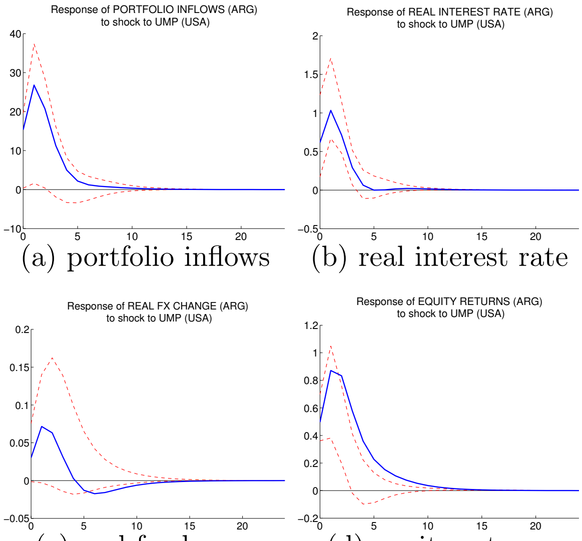


(a) real GDP growth (b) portfolio inflows

(c) real interest rate (d) real fx change

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the BC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.6: Responses of Argentina's variables to U.S. UMP shock – model: FC

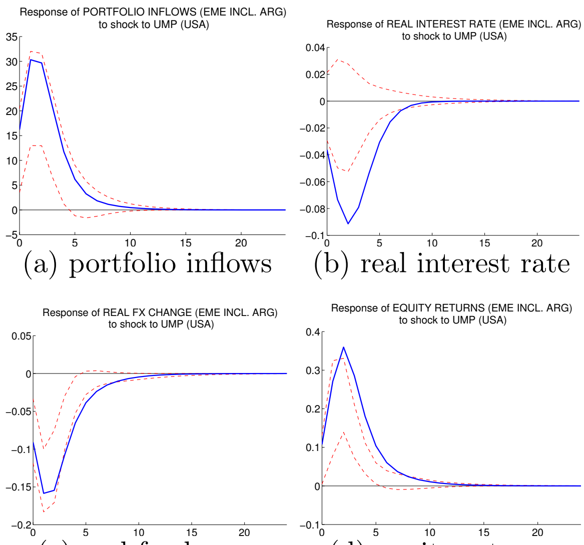


(a) portfolio inflows (b) real interest rate

(c) real fx change (d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the FC model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.7: Responses of EME variables (mean including Argentina) to U.S. UMP shock – model: FC

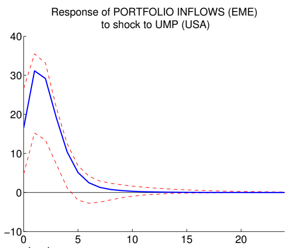


(a) portfolio inflows (b) real interest rate

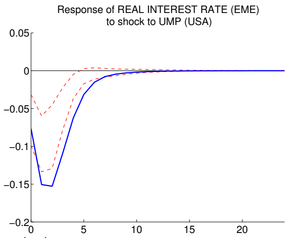
(c) real fx change (d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

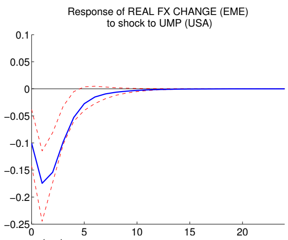
Figure 1.C.8: Responses of EME variables (mean) to U.S. UMP shock – model: FC with portfolio flows as only cross-country transmission channel



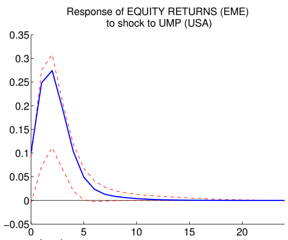
(a) portfolio inflows



(b) real interest rate



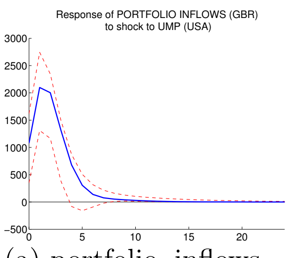
(c) real fx change



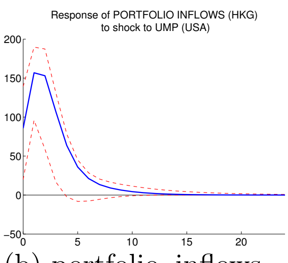
(d) equity returns

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the financial conditions (FC) model with portfolio flows as the only foreign variable. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.9: Responses of portfolio inflows to the United Kingdom and to Hong Kong – model: FC



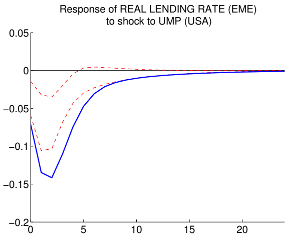
(a) portfolio inflows - United Kingdom



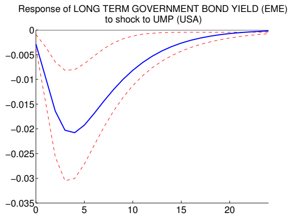
(b) portfolio inflows - Hong Kong

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

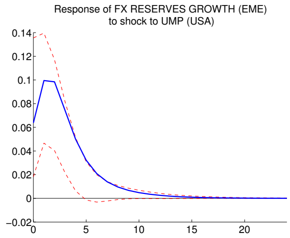
Figure 1.C.10: Responses of alternative measures of financial conditions



(a) real lending rate



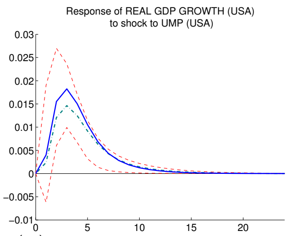
(b) long-term gov. bond yield



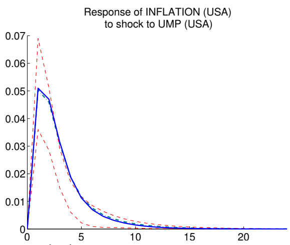
(c) fx reserve growth

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the depicted variables to a one standard deviation UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

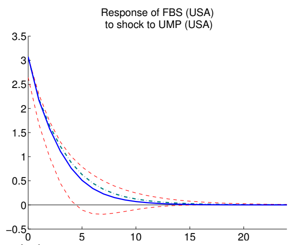
Figure 1.C.11: Responses of U.S. variables to U.S. UMP shock – model: FC, counterfactural exercise with restriction to portfolio flows



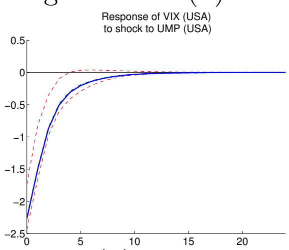
(a) real GDP growth



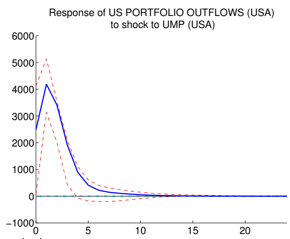
(b) inflation rate



(c) Fed balance sheet



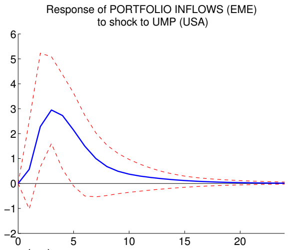
(d) VIX



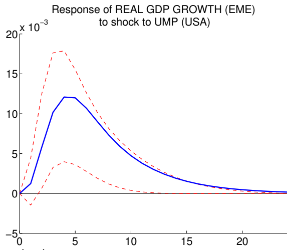
(e) portfolio outflows

Note: The figure shows the estimated impulse responses (blue solid line) and the 68 percent confidence bands (red dashed line) of the EME variables to the UMP shock in the financial conditions (FC) model of the depicted variables to a one standard deviation UMP shock in the financial conditions (FC) model, along with the corresponding impulse responses in the same model where the transmission through capital flows is counterfactually turned off (green dash-dotted line, see Section 1.3.5).

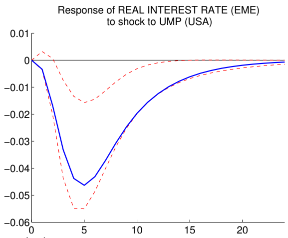
Figure 1.C.12: Responses of EME variables (mean) to U.S. UMP shock - model: BC with GDP as only foreign variable



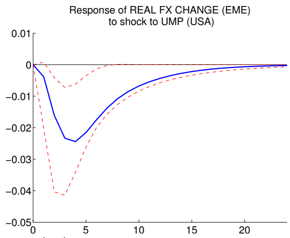
(a) portfolio inflows



(b) real GDP growth



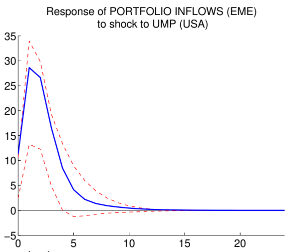
(c) real interest rate



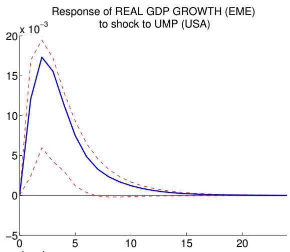
(d) real fx change

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the business cycle (BC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

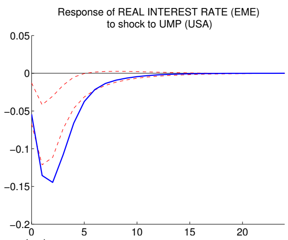
Figure 1.C.13: Responses of EME variables (mean) to U.S. UMP shock - model: BC model with portfolio flows as only foreign variable



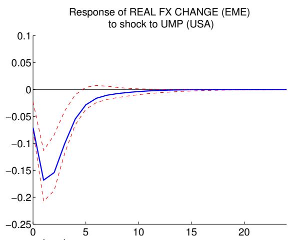
(a) portfolio inflows



(b) real GDP growth



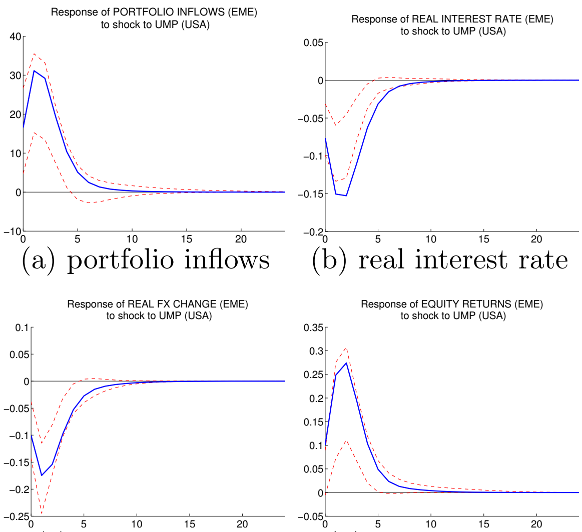
(c) real interest rate



(d) real fx change

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the business cycle (BC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.14: Responses of EME variables (mean) to U.S. UMP shock - model: FC with portfolio flows as only foreign variable

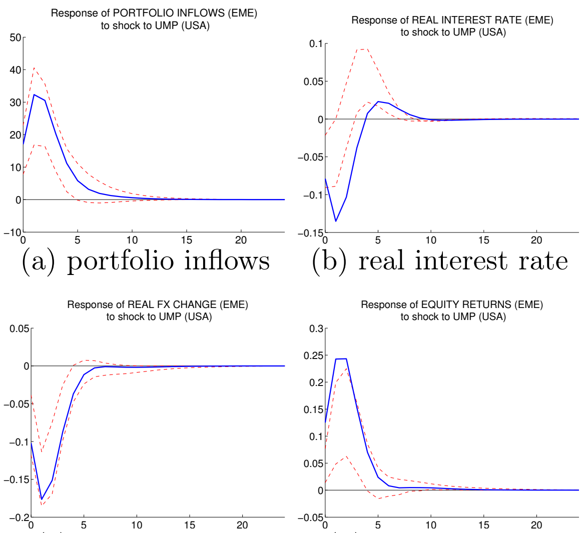


(a) portfolio inflows (b) real interest rate

(c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.15: Responses of EME variables (mean) to U.S. UMP shock - model: FC with portfolio flows and foreign interest rates as foreign variables

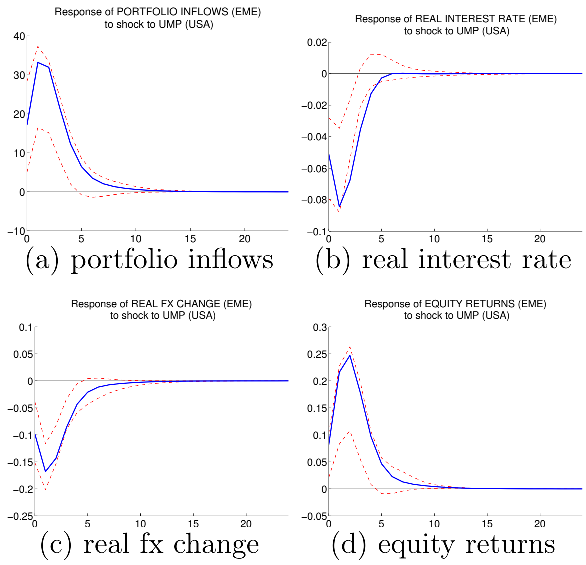


(a) portfolio inflows (b) real interest rate

(c) real fx change (d) equity returns

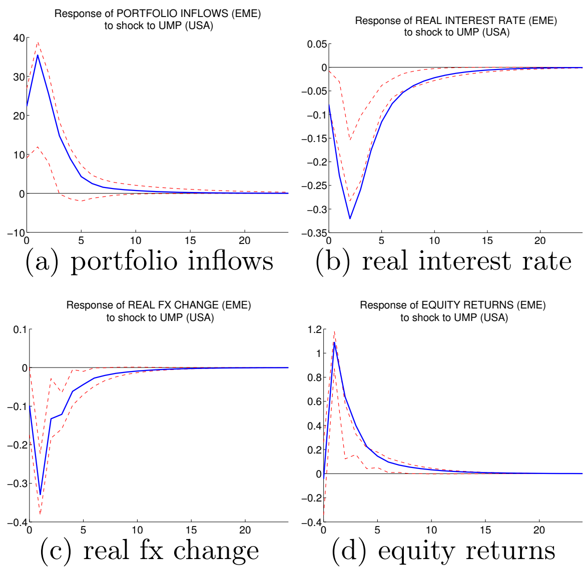
Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.16: Responses of EME variables (mean) to U.S. UMP shock - model: FC with portfolio flows and foreign lending rates as foreign variables



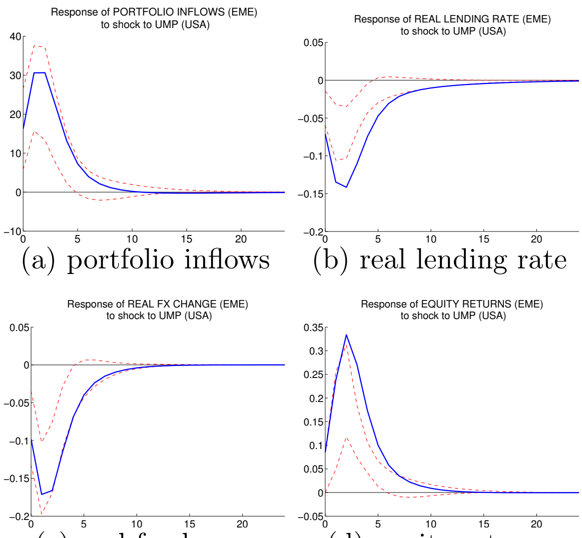
Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.17: Responses of EME variables (mean) to U.S. UMP shock - model: FC with portfolio flows and foreign equity returns as foreign variables



Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.18: Responses of EME variables (mean) to U.S. UMP shock - model: FC with lending rate

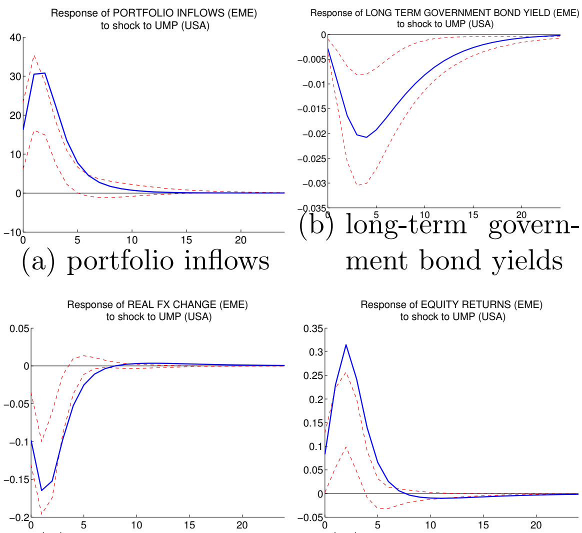


(a) portfolio inflows (b) real lending rate

(c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.19: Responses of EME variables (mean) to U.S. UMP shock - model: FC with long term government bond yields

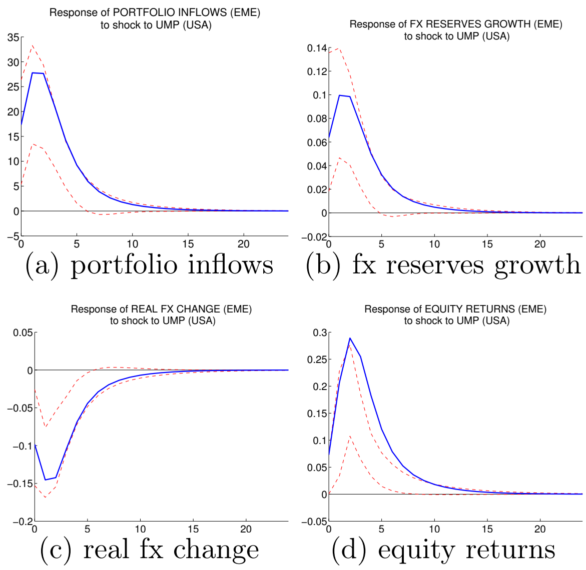


(a) portfolio inflows (b) long-term government bond yields

(c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.20: Responses of EME variables (mean) to U.S. UMP shock - model: FC, fx reserves as monetary policy instrument in EMEs

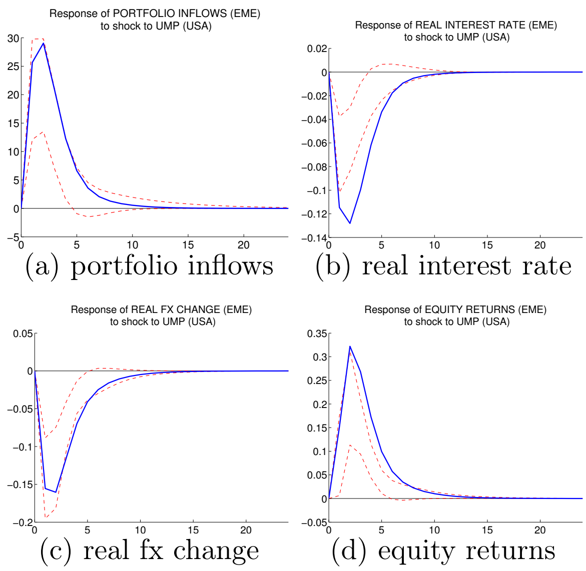


(a) portfolio inflows (b) fx reserves growth

(c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.21: Responses of EME variables (mean) to U.S. UMP shock - model: FC, U.S. portfolio outflows ordered before monetary policy variables

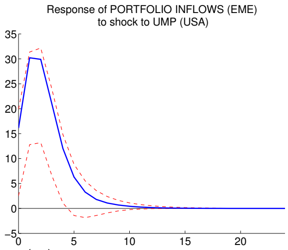


(a) portfolio inflows (b) real interest rate

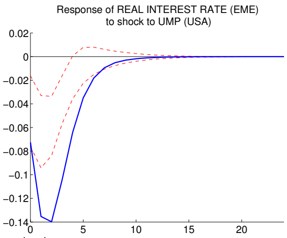
(c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

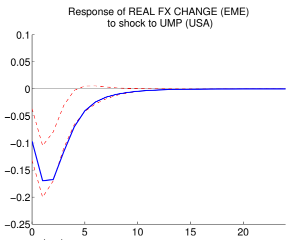
Figure 1.C.22: Responses of EME variables (mean) to U.S. UMP shock - model: FC, Argentina is dropped from the estimation



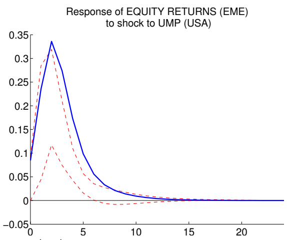
(a) portfolio inflows



(b) real interest rate



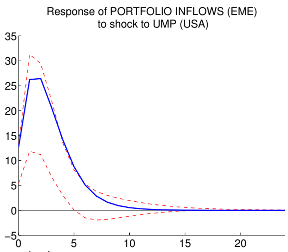
(c) real fx chagne



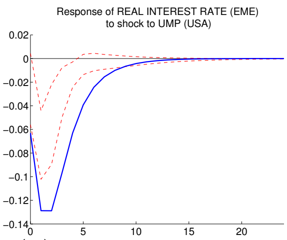
(d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

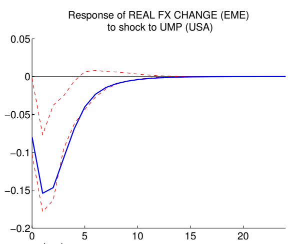
Figure 1.C.23: Responses of EME variables (mean) to U.S. UMP shock - model: FC, alternative lag length



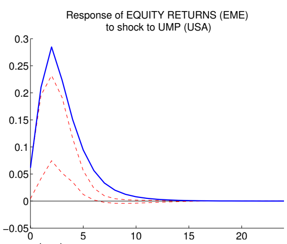
(a) portfolio inflows



(b) real interest rate



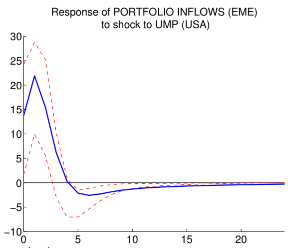
(c) real fx chagne



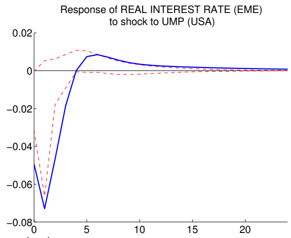
(d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

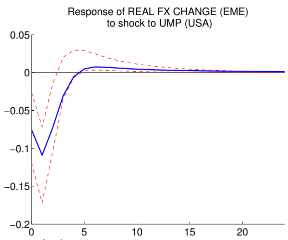
Figure 1.C.24: Responses of EME variables (mean) to U.S. UMP shock - model: FC, post-Lehman sample



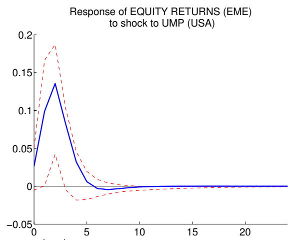
(a) portfolio inflows



(b) real interest rate



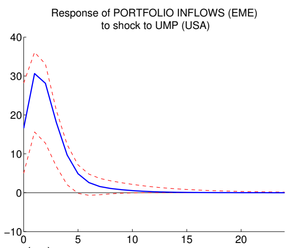
(c) real fx change



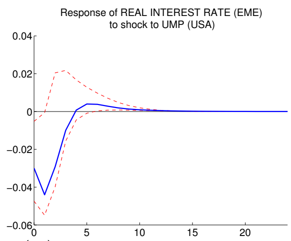
(d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

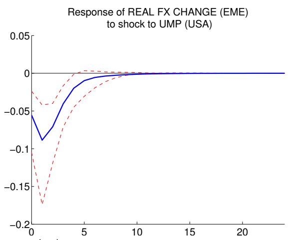
Figure 1.C.25: Responses of EME variables (mean) to U.S. UMP shock - model: FC, commodity price inflation & portfolio flows as transmission channels



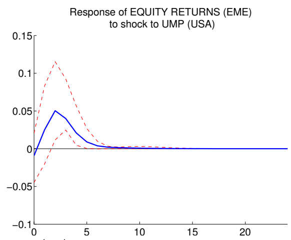
(a) portfolio inflows



(b) real interest rate



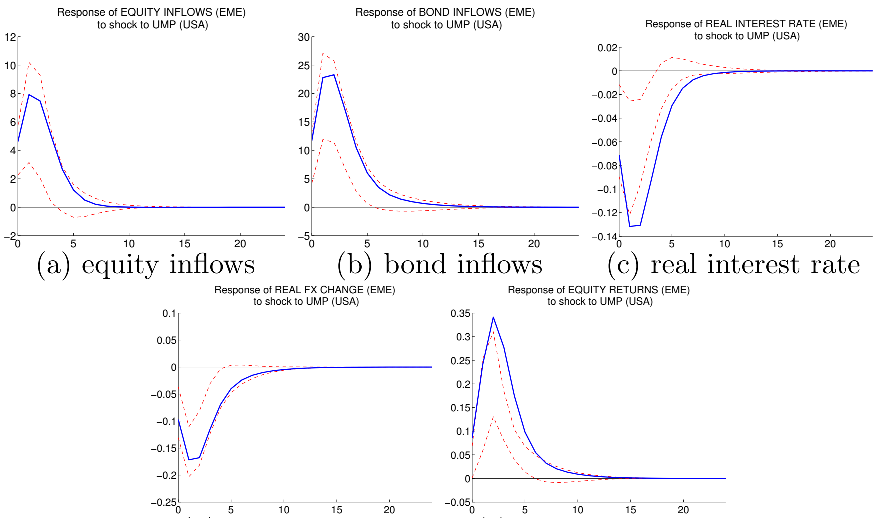
(c) real ifx change



(d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

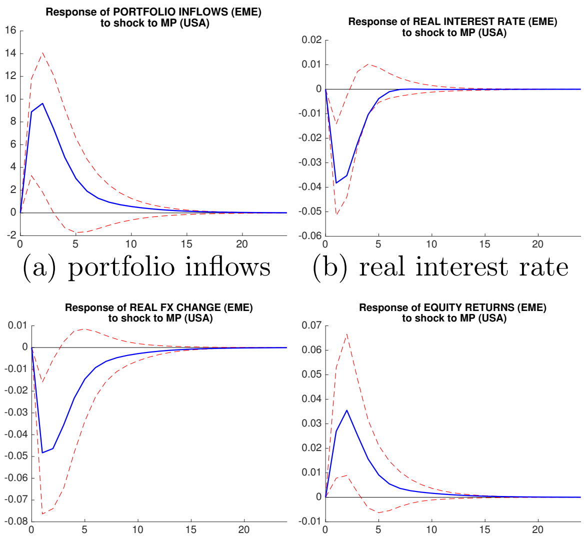
Figure 1.C.26: Responses of EME variables (mean) to U.S. UMP shock - model: FC, equity and bond flows



(a) equity inflows (b) bond inflows (c) real interest rate (d) real fx change (e) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

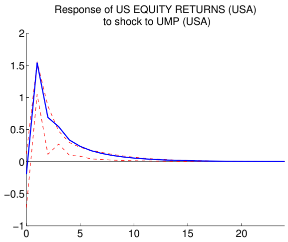
Figure 1.C.27: Responses of EME variables (mean) to U.S. UMP shock - model: FC, shadow federal funds rate as monetary policy instrument in the U.S.



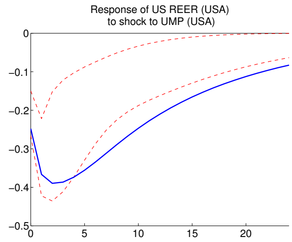
(a) portfolio inflows (b) real interest rate (c) real fx change (d) equity returns

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

Figure 1.C.28: Responses of U.S. equity returns and U.S. REER to U.S. UMP shock



(a) US equity returns



(b) U.S. reer

Note: The figure shows the estimated mean impulse responses, along with 68 percent confidence bands, of the EME variables to the UMP shock in the financial conditions (FC) model. Confidence bands are based on 500 bootstrap replications with 1000 draws of the rotation matrix each.

1.D Additional tables

Table 1.D.1: Panel unit root tests

	t-stat	critical values (1% / 5% / 10%)	Type	Det
IP	-3.84	-2.73 / -2.63 / -2.56	2	3
D(IP)	-11.35	-2.24 / -2.13 / -2.06	2	2
Real GDP	-1.77	-2.73 / -2.63 / -2.56	2	3
D(Real GDP)	-5.59	-2.25 / -2.13 / -2.06	2	2
CPI	-1.98	-2.73 / -2.63 / -2.56	2	3
D(CPI)	-8.21	-2.25 / -2.13 / -2.06	2	2
Portfolio Inflows	-8.01	-2.25 / -2.13 / -2.06	2	2
D(Portfolio Inflows)	-8.11	-1.70 / -1.56 / -1.47	2	1
U.S. Portfolio Outflows	-6.14	-3.52 / -2.90 / -2.58	0	2
D(U.S. Portfolio Outflows)	-11.25	-2.58 / -1.95 / -1.62	0	1
VIX	-2.62	-3.52 / -2.90 / -2.58	0	2
D(VIX)	-8.39	-2.60 / -1.95 / -1.62	0	1
Fed Balance Sheet	-3.74	-4.09 / -3.47 / -3.17	0	3
D(Fed Balance Sheet)	-1.79	-3.54 / -2.90 / -2.59	0	2
Real Interest Rate	-8.09	-2.25 / -2.13 / -2.05	2	2
D(Real Interest Rate)	-14.90	-1.70 / -1.56 / -1.47	2	1
Equity Price Index	-2.49	-2.73 / -2.63 / -2.56	2	3
D(Equity Price Index)	-10.01	-2.25 / -2.13 / -2.06	2	2
Real FX	-2.10	-2.25 / -2.13 / -2.06	2	2
D(Real FX)	-12.05	-1.70 / -1.56 / -1.47	2	1

Type: Type of panel unit root test,
2 = P-CEA test controlling for cross-section dependence of errors,
1 = IPS test under the assumption of no cross-section dependence,
0 = simple ADF test for cross-section invariant data.
Det: Deterministics case for the test regression,
3 = with const and trend, 2 = with constant, 1 = without deterministics.

CHAPTER 2

Foreign Currency Exposure and the Financial Channel of Exchange Rates[1]

2.1 Introduction

The onset of the Global Financial Crisis, the implementation of extraordinarily expansionary monetary policies across the world and the recent monetary tightening in the U.S. have renewed the interest in the effects of global and foreign shocks in small open economies (SOEs). One important international transmission mechanism of such shocks are USD exchange rate fluctuations (Iacoviello and Navarro, 2019; Ben Zeev, 2019). But, how do exchange rate movements affect macroeconomic and financial conditions? Exchange rate movements can affect the economy through exports and imports (the trade channel) and through valuation effects of assets and liabilities denominated in foreign currency (the financial channel). It has been conventional wisdom in international macroeconomics that a domestic appreciation has contractionary effects on the economy due to a decrease in net exports, other things being equal.[2] However, because of the ever higher degree of financial

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[2]Under certain conditions, a domestic appreciation can also be expansionary in the absence of the financial channel. See Section 2.3.

integration,[3] foreign currency exposure has gained more attention (Bénétrix et al., 2015), and therefore the relevance of exchange rate movements operating through the financial channel has increased (Bruno and Shin, 2015b; Hofmann et al., 2017). Crucially, the financial channel can potentially work in the opposite direction of the trade channel (Avdjiev et al., 2019), since it operates through the liability side of a country's external balance sheet. Thus, under foreign currency exposure, a domestic appreciation decreases the value of liabilities relative to assets. This strengthens the external balance sheet, which loosens financial conditions and ultimately stimulates investment and GDP (Avdjiev et al., 2019).[4]

The aim of this paper is to empirically assess the macroeconomic and financial effects of USD exchange rate movements in small open economies (SOEs).[5] In particular, I study how the financial channel affects the overall impact of exchange rate fluctuations, under which conditions it dominates the trade channel, and to what extent foreign currency exposure – i.e. liabilities denominated in USD – determines its strength. After showing the effects of the financial channel, I evaluate whether it amplifies or dampens the effects of foreign monetary policy shocks. I structure the analysis to answer the following consecutive research questions: *(i)* What are the overall macroeconomic and financial effects of USD exchange rate movements in SOEs? *(ii)* Under which conditions does the financial channel dominate the trade channel? *(iii)* What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE? I focus on the USD exchange rate since it is by far the most important currency in international trade and finance, that is why it is well suited to capture effects working through trade and financial market relations. To answer the questions, I propose a new identification scheme for USD exchange rate shocks to individual SOEs and use Local Projections - Instrumental Variable (henceforth LP-IV) methods. Furthermore, to obtain a structural interpretation of the empirical findings and be able to analyze the trade and financial

[3] For details, see Figure 2.3.1 in Section 2.3, which shows the rise of financial openness over the past two decades, defined as the sum of assets and liabilities in foreign currency as a percent of GDP.

[4] See Section 2.3 for details.

[5] The small open economies in my sample are: Brazil, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand, and Turkey.

channels in detail, I estimate a small open economy New Keynesian model with financial frictions and currency mismatch in the banks' balance sheets.

Exchange rate movements are highly endogenous to macroeconomic conditions, therefore it is challenging to empirically assess their effects. To deal with this problem, I construct an external instrument and identify exchange rate shocks that are specifically related to the USD exchange rate and are exogenous to the set of SOEs in my sample. The shocks that I identify can be interpreted as changes in the bilateral USD exchange rate unrelated to individual SOEs' fundamentals or global driving forces, or as exogenous foreign asset demand shocks, or as financial shocks affecting foreign exchange market (Engel, 2014; Itskhoki and Mukhin, 2017). In contrast to the existing literature (Iacoviello and Navarro, 2019; Ben Zeev, 2019), this identification scheme allows me to study how exchange rates - through the financial and trade channels - affect the economy independently from the effects than could arise from exchange rate movements due to monetary policy or global credit supply shocks.

I proceed as follows. I consider the effective exchange rate of the USD against a basket of currencies of other advanced economies (like the Euro Area, UK, Japan, among others). This series should be unrelated to the fundamentals of the SOEs in my sample for two reasons. First, the exchange rates of these SOEs are not used to construct the USD exchange rate against major currencies. Second, under the small open economy assumption, the countries in my sample are too small to influence this exchange rate. I regress this series on interest rate differentials, as in the uncovered interest rate parity (UIP) condition, on macroeconomic variables of the countries in the basket of currencies, and on global driving forces affecting the currencies and macroeconomic conditions in the U.S. and in the other advanced economies. The resulting residuals are orthogonal to those fundamentals and hence represent shocks to the UIP condition between the U.S. and other major economies (U.S. risk premium shocks).[6] These UIP shocks are often used in the DSGE literature to proxy exchange rate shocks (see, e.g. Kollmann, 2005). I then use the residual series as an external instrument in a panel LP-IV setting. Having identified the UIP shock, I study how exogenous USD exchange rate movements unrelated to SOEs' fundamentals and global conditions affect real and financial variables in SOEs.

[6]Note that I use the terms UIP shock and risk premium shock interchangeably.

The empirical analysis reveals the following results. For a panel of SOEs, I find that a domestic appreciation against the USD *increases* real GDP and loosens financial conditions in SOEs. This finding indicates the importance of the financial channel. The appreciation goes hand-in-hand with a rise in domestic real investment, equity prices, credit and cross-border bank flows. Moreover, the increase in real GDP occurs despite a deterioration of the trade balance consistent with the trade channel. To examine the determinants of this result, I assess the sensitivity of the baseline results to several indicators that reflect the intensity of international financial linkages and international trade. First, I analyze whether the results depend on foreign currency exposure, measured by the amount of liabilities denominated in USD as percent of GDP. I find that in countries with relatively high liabilities in USD (e.g. Brazil, Colombia, or the Philippines), the financial channel dominates, as the domestic appreciation against the USD leads to an increase of real GDP, real investment, real consumption, and to a loosening of financial conditions, despite the decrease in net exports. By contrast, in countries with relatively low liabilities in USD (e.g. Poland, Hungary or India), the appreciation is contractionary, as implied by the trade channel. Further, I investigate whether the results depend on the amount of foreign assets denominated in USD, or on variables that should indicate the strength of the trade channel, such as trade openness and the amount of trade with the U.S. I do not find evidence that any of these characteristics affect the transmission channel of exchange rates. Summing up, for my sample of SOEs, I find that an appreciation can be expansionary due to the financial channel of exchange rates, whose strength is determined by exposure to USD liabilities.

Next, I estimate an open economy New Keynesian model with financial frictions, in which a fraction of the domestic banks' debt is denominated in USD, similar to Aoki et al. (2016), Mimir and Sunel (2019) and Akinci and Queralto (2018). As it is the case in standard open economy DSGE models, fluctuations in the exchange rate have an effect on the trade balance, as relative prices of exports and imports change. However, in my model, exchange rate fluctuations also affect the banks' balance sheets as their assets are denominated in domestic currency and their liabilities are denominated in part in USD. Thus, an appreciation of the domestic currency reduces the value of foreign currency exposure, strengthening borrowers' balance sheets, which in turn exerts upward pressure on the value of the local currency.

This feature of the model allows a careful analysis of the effects of exchange rate movements through the financial channel. Since the model accounts for both a trade and a financial channel, I can study to what extent exposure to USD liabilities and trade openness determine the relative strength of the channels. Finally, with the estimated open economy New Keynesian model at hand, I also investigate how the financial channel of exchange rates affect the transmission of foreign monetary policy shocks.

For the estimation of the model I use Brazilian (high exposure to USD liabilities and relatively low trade openness) and Polish data (low exposure to USD liabilities and high trade openness).[7] I then analyze the effects of a UIP risk-premium shock. In line with the empirical results, I find that the level of foreign currency exposure is an important determinant of the strength of the financial channel. However, in contrast to the LP-IV analysis, the estimated DSGE models for Brazil and Poland indicate that the trade channel, trough trade openness, also determines whether an appreciation is expansionary or contractionary. Specifically, I show that a shock to the UIP condition, which induces a domestic appreciation against the USD, is expansionary in Brazil. However, if Brazil would become more open to trade, the expansionary effects of the appreciation become weaker, and eventually disappear. By contrast, the appreciation against the USD is contractionary in Poland. However, if Poland's exposure to USD liabilities increases sufficiently, the result flips and the appreciation becomes expansionary. Thus, the model based analysis suggests that it is the interaction between the financial and trade channels that determines the effects of exchange rate appreciations in SOEs. Finally, I also find that the foreign currency exposure and the financial channel amplify the effects of foreign monetary policy, in line with the results of Iacoviello and Navarro (2019).

The results from the LP-IV and the New Keynesian model estimation indicate that the financial channel can potentially challenge the conventional wisdom about the effects of a domestic appreciation, which is solely based on the relationship between exchange rates and the trade balance. The resulting decrease in net exports does not necessarily lead to a macroeconomic contraction, since – under foreign

[7]Earlier versions of this paper contained results for Hungarian data. However, due to significant inconsistencies in the data for Hungary's debt and liabilities in USD (see below), the current version contains the results for Poland. Note that the conclusions I draw from the estimation with Polish data are identical to those I draw from the estimation with Hungarian data.

currency exposure – financial conditions loosen, and investment and real GDP may increase. The level of liabilities denominated in USD is an important factor driving these results: the higher foreign currency exposure is, the stronger the financial channel. My findings have several implications. First, it is necessary to consider the level of foreign currency exposure and thus the strength of the financial channel to understand the effect of exchange rate movements. Second, the financial channel has strong effects on domestic financial conditions and potentially amplifies the effects of foreign shocks. Since policy-markers are often concerned with financial stability and the transmission of foreign shocks, they need to consider the financial channel in order to design and implement policies aimed at ensuring the stability of the domestic financial system and dampening the effects of foreign shocks. Finally, as documented by other studies (e.g. Aoki et al., 2016; Mimir and Sunel, 2019), the financial channel and its effects potentially justify the implementation of active macroprudential policies to manage the effects arising from the interaction between USD exchange rate fluctuations, foreign currency debt and domestic financial conditions.

The remainder of the paper is structured as follows. In Section 2.2, I review the related literature. In Section 2.3, I describe the channels through which exchange rate movements affect macroeconomic conditions. Section 2.4 contains a description of the data, the construction of the external instrument that I use to identify exogenous exchange rate movements and the results from the LP-IVs. Section 2.5 describes the New Keynesian model setup, its estimation and the results drawn from this analysis. The last section concludes.

2.2 Related literature

My work is related to different strands of the existing literature. Naturally, it relates to papers that also study the effects of exchange rate movements on macroeconomic and financial conditions using SVARs (see e.g. Choudhri et al., 2005; Farrant and Peersman, 2006; Kim and Ying, 2007; Fratzscher et al., 2010; Forbes et al., 2018, Corbo and Di Casola, 2018). These studies, however, use Choleski decomposition or sign restrictions to identify exogenous exchange rate shocks. Just by ordering the exchange rate last, however, a Choleski decomposition offers no assurance that the exchange rate shock is indeed unrelated to other fundamentals, possibly not captured in the VAR. Sign restrictions, on the other hand, are often not satisfying as, for instance, monetary policy shocks and exchange rate shocks could theoretically imply the same sign pattern on standard variables in the VAR. My identification strategy, in contrast, relies on an external instrument that is unrelated to the fundamentals of the SOEs in my sample and to common driving forces.

A similar approach is used in a recent study by Lane and Stracca (2017). They study the effects of exchange rate movements on macroeconomic conditions in Euro area counties, mainly focusing on the trade channel. To identify the exogenous movements in the exchange rate in individual countries, they use Euro area-wide effective exchange rate as an external instrument. My paper, in contrast, focuses on SOEs outside the euro area and not only on macroeconomic effects, but also on financial variables that affect shock transmission through the external balance sheet of countries. Further, my paper is also related to the body of work studying the effects of exchange rate movements through the trade channel. Surveys of this extensive literature can be found in Auboin and Ruta (2012) or Leigh et al. (2017).

The models I employ to answer my research questions offer an overall assessment of the effects of currency movements on macroeconomic and financial conditions, hence my paper directly connects to the recent and fast growing literature on the financial channel. Georgiadis and Mehl (2016), for instance, find that the impact of an expansionary domestic monetary policy shock is amplified in countries with large net long foreign currency exposure. This is so because a monetary loosening triggers a depreciation of the domestic exchange rate, which in turn strengthens the external balance sheets of such countries. Bruno and Shin (2015b) and Hofmann et al. (2017) show theoretically that if a valuation mismatch in private sector balance sheets in emerging market economies (EMEs) exists, movements in the bilateral USD exchange rate can affect financial conditions in EMEs, and thus real variables. They refer to this as the 'risk-taking channel' of exchange rate appreciation. Hofmann et al. (2017) and Bruno and Shin (2015b) find some empirical evidence for this channel with cross-country panel regression and a Choleski identified VAR. Specifically, Hofmann et al. (2017) show that a currency appreciation against the USD is on average associated with a compression of EMEs' sovereign bond yields and larger portfolio inflows into EMEs. I extend their research by applying a comprehensive model that allows to capture the effects of both, the trade and financial channels, and by identifying (exogenous) exchange rate movements in a more compelling way than a Choleski decomposition. Related to these studies, Avdjiev et al. (2019) study the effects of movements in the USD exchange rate on cross-border banking flows and investment. They conduct this analysis using, again, a Cholesky identified panel SVAR and panel regressions. Iacoviello and Navarro (2019) and Ben Zeev (2019) also study the trade and financial channels, but in contrast to my study, they investigate the effects of a U.S. monetary policy shock and a global liquidity shock, respectively. Also, Bernoth and Herwartz (2019) study the effects of exchange rate movements on sovereign risk in EMEs, and find that a depreciation of the domestic currency against the USD increases sovereign risk. Moreover, they show evidence showing that foreign currency exposure is a key determinant for the size of the fall in risk. Further, my work is related to the global financial cycle and on international spillovers of U.S. monetary policy, for instance Rey (2016), Miranda-Agrippino and Rey (2015), Bruno and Shin (2015a), Georgiadis (2015b), and Anaya et al. (2017), among others.

Moreover, my paper broadly relates to an extensive body of work on open economy New Keynesian models (Galí and Monacelli, 2005, Farhi and Werning, 2014, among others), and on their estimation (Adolfson et al., 2007, Justiniano and Preston, 2010). My DSGE model extends recent work by Aoki et al. (2016), Akinci and Queralto (2018), and Mimir and Sunel (2019), who study the effects of foreign shocks and the implementation of optimal policy responses in a calibrated open economy DSGE setting with currency mismatch in the bank's liabilities. Furthermore, my paper also relates to Copaciu et al. (2015), who develop and estimate a model for the Romanian economy where part of the debt is denominated in euro, and to Gourinchas (2018) who develops and estimates a model for the Chilean economy and assesses the role of trade and financial openness in the transmission of foreign shocks. Finally, this paper is also related to Dalgic (2018), who uses an open economy DSGE model to investigate the role of households' savings in foreign currency on as an insurance arrangement.

2.3 The trade and financial channel of exchange rate movements

To answer this paper's research questions, first it is necessary to explain the mechanisms through which the financial and trade channels affect the economy, and what are their effects on macroeconomic and financial variables.

2.3.1 The trade channel

The trade channel, or expenditure switching channel, reflects the relationship between exchange rate fluctuations and the trade balance. This channel is the key transmission mechanism of exchange rates in frameworks such as, e.g. the Mundell-Fleming model and open economy New Keynesian models. Consider, for example, a deviation from the UIP condition that causes the domestic exchange rate to appreciate. This raises the price of exports while it decreases the price of imports. If the Marshall-Lerner condition holds,[8] the appreciation leads to demand substitution away from domestic goods towards foreign goods, thus lowering the trade balance and GDP. [9]

2.3.2 The financial channel

The so-called financial channel has become more relevant over time, as global financial integration has increased. Figure 2.3.1 shows the evolution of financial and trade openness, defined as foreign liabilities and assets over GDP, and exports and imports over GDP, respectively, for a broad group of advanced economies and EMEs.[10] Panel (a) shows that trade openness has increased in the past three decades, how-

[8]The Marshall-Lerner condition states that an exchange rate appreciation deteriorates the balance of trade if the absolute sum of the long-term export and import demand elasticities is greater than one.

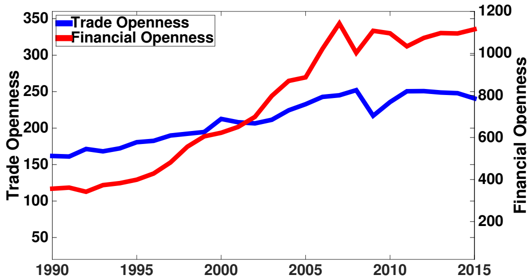
[9]However, as highlighted by Lane and Stracca (2017), an appreciation of the exchange rate can also be expansionary through the trade channel if the following effects dominate the decrease in net exports. The appreciation (1) lowers the price of imported intermediaries sufficiently much such that the production of tradables is considerably less expensive, which in turns increases overall net exports, and (2) consumption rises significantly due to overall lower price of imports. Generally speaking, the trade channel suggests that an appreciation of the exchange rate is contractionary (see Iacoviello and Navarro, 2019; Ben Zeev, 2019).

[10]For details on the construction of the data, see BIS (2017).

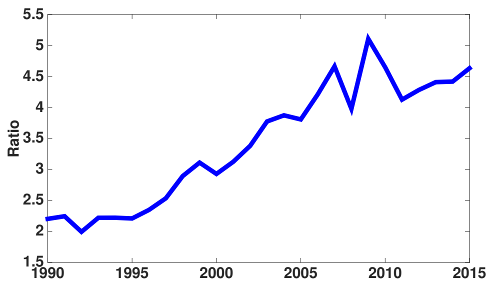
ever, financial openness has outpaced trade, and roughly tripled since 1990. This development is shown in Figure 2.3.1b. The ratio of financial openness to trade openness has more than doubled from 1995 to 2015. This hints to the potentially rising relevance of the financial channel.

Figure 2.3.1: Financial and Trade Openness

(a) Financial and Trade Openness



(b) Ratio Financial Openness to Trade Openness



Note: Panel (a) shows financial openness (red line, defined as foreign liabilities + assets as a percent of GDP, with the value in 1960 = 100) and trade openness (blue line, defined as exports + imports as a percent of GDP, with the value in 1960 = 100) for a broad group of advanced economies and emerging market economies. Panel (b) shows the ratio of financial openness to trade openness. Source: Own elaboration with data from the BIS. For details see BIS (2017).

Moreover, after the Asian financial crisis, EMEs started to increase their net foreign currency positions by accumulating foreign exchange reserves through current account surpluses and a shift from debt liabilities to equity-type liabilities (Lane and Shambaugh, 2010; Hausmann and Panizza, 2011; Bénétrix et al., 2015). This improvement in the net currency exposure masks heterogeneity across sectors in the economy (Avdjiev et al., 2015). While governments and central banks in EMEs have increasingly accumulated foreign exchange reserves, the private sector can still be a large debtor in foreign currency, in particular in USD.[11] This USD-denominated debt is often backed by assets and cash-flows in local currency, creating a valuation mismatch on corporate balance sheets.[12] These developments have not only been confined to EMEs. Assets and liabilities denominated in foreign currency have also

[11]The stock of USD-denominated debt of non-banks in EMEs was estimated to be $ 3.3 trillion as of March 2015 (McCauley, McGuire and Sushko, 2015).

[12]A comprehensive discussion of valuation mismatches in EMEs' corporate balance sheets can be found in Avdjiev et al. (2015).

increased in countries like Canada, Sweden, South Korea and others (Bénétrix et al., 2020). However, as Kearns and Patel (2016) argue, EMEs are particularly vulnerable to adverse effects arising from currency mismatch in their external balance sheets due to their relatively less developed financial systems and the consequent tendency to have unhedged foreign currency debt.[13]

The financial channel captures the idea that exchange rate fluctuations affect macroeconomic and financial conditions also through valuation effects in a country's external balance sheet. Thus, the currency denominations of the assets and liabilities in the external balance sheet and possible currency mismatches determine whether, for instance, an appreciation of the domestic exchange rate is potentially expansionary or contractionary through this channel.

Avdjiev et al. (2019) argue that the key empirical regularity behind the financial channel is that an appreciation of a country's currency against the USD is associated with an increase of borrowing denominated in USD in that country. Thus, Avdjiev et al. (2019) indicate that the financial channel mainly operates through the liability side of the balance sheet of domestic borrowers. Therefore, if a country has (net) foreign currency exposure, specially in USD, an exchange rate appreciation against the USD can potentially be expansionary, as the value of liabilities decreases relative to the (in domestic currency denominated) assets.

Moreover, there are two ways in which the financial channel – working through the liabilities in the external balance sheet – affects the impact of exchange rate fluctuations: via supply and demand for USD (Avdjiev et al., 2019). On the supply side, Bruno and Shin (2015b), and Hofmann et al. (2017) suggest that an appreciation of the local currency against the USD affects financial conditions by making borrowers' balance sheets look stronger and thus by increasing their creditworthiness. In turn, the willingness of foreign creditors to extend credit increases for any given exposure limit,[14] which raises capital and banking inflows and subsequently credit supply. This mechanism is what Hofmann et al. (2017) call the 'risk taking channel' of currency appreciation. On the demand side, Avdjiev et al. (2019) point

[13]Moreover, due to the same reason, EMEs may be more dependent on foreign funds. Chapter 3 in this dissertation deals with this latter issue.

[14]Such exposure limits can be associated with value-at-risk constraints in the (global) banking sector (Bruno and Shin, 2015b) or if fund investments of asset managers with a global reach fluctuate with recent market conditions (see Hofmann et al., 2017).

out that a domestic borrower who had borrowed in USD, will see her balance sheet strengthen as the domestic currency appreciates and the USD depreciates.[15] In any case, the financial channel - working through the liabilities - implies that an exchange rate appreciation against the USD increases capital and banking flows, and loosens financial conditions, which stimulates investment and GDP.

On the other hand, it is conceivable that a domestic appreciation can also be contractionary through the financial channel. This would be the case if a country's assets are denominated in USD, and its liabilities mostly denominated in domestic currency. An appreciation of the home currency against the dollar would trigger a relative decrease in the value of the assets, and thus financial conditions worsen, which reinforces the contractionary trade-channel (Georgiadis and Mehl, 2016). However, Kearns and Patel (2016) argue that the valuation effects on the liabilities side have a larger impact on the economy in EMEs, since assets in USD are held by long-term investors, such as foreign exchange reserve managers, pension funds and central banks. Thus, valuation changes in assets are likely to lead to smaller changes in spending and, consequently, exposure to USD liabilities may be the main determinant of the financial channel's strength.

2.4 Data, identification strategy and results

2.4.1 Data on exchange rates, macroeconomic and financial conditions

The data set that I use consists of quarterly data, covering 17 SOEs from 1998 - 2019. The panel for the empirical analysis in unbalanced. The countries in my sample resemble the sample of many studies on EMEs (see, for instance, Aizenman et al., 2016) and contains the following EMEs and other SOEs: Brazil, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand, and Turkey. For the LP-IV analysis, I use times series for real GDP, real private consumption, real gross fixed capital formation, trade balance as a percentage of GDP, equity prices (MSCI equity

[15] Avdjiev et al. (2019) also argue that, even an exporting firm whose receivables are in USD and obligations in domestic currency would incur in USD liabilities if the USD is expected to depreciate more, in order to hedge further currency risks. This would lead to the same outcome as explained above.

price index), credit to the private sector as a percentage of GDP, the nominal policy interest rate, the consumer price index, and the VIX. I also use the gross cross-border banking data of the Bank for International Settlemests' (BIS), and the shadow Federal Funds Rate by Wu and Xia (2016).[16] All series are seasonally adjusted. Furthermore, I use the data on the amount of assets and liabilities in USD (as percent of GDP) by Bénétrix et al. (2015) and by Bénétrix et al. (2020).[17] I also use the financial vulnerability index and data on the trade intensity with the U.S. constructed by Iacoviello and Navarro (2019).

To construct the instrument for the exogenous exchange rate movements I use the USD effective exchange rate against major economies,[18] the VIX and time series for real GDP, consumer price index, policy interest rate of the U.S. and the other eight other major economies, as well as equity price indices and a commodity price index. For the period of the zero lower bound, I use shadow rates for all the countries for which the data are publicly available.[19]

2.4.2 An instrument to identify exogenous exchange rate movements

Since the focus of this paper is on USD exchange rate fluctuations against SOEs' currencies, I need an instrument to identify exogenous exchange rate movements specific to the USD. Besides fulfilling the LP-IV conditions discussed below (Stock and Watson, 2018), such an instrument needs to be in line with certain economic considerations in order to be useful for the empirical analysis. First, the instrument should move the USD exchange rate against all currencies in the sample, and therefore represent an overall appreciation or depreciation of the USD against all the

[16]The details on the data and the sources are on Table 2.A.1 in Appendix 2.A.

[17]The data by Bénétrix et al. (2020) end in 2017. Thus I use the last value of assets and liabilities in 2017 for the rest of my sample. One exception is the data for Hungary. Due to the large discrepancies between Bénétrix et al. (2020) and Bénétrix et al. (2015) in the estimation of liabilities in USD for Hungary, in this case I use the data estimated by Bénétrix et al. (2015), which end in 2013. I use the value of 2013 for the rest of the sample.

[18]The major currencies index includes the Euro Area, Canada, Japan, United Kingdom, Switzerland, Australia, and Sweden.

[19]As mentioned above, for the U.S. I use the shadow FFR by Wu and Xia (2016). Moreover, for the Euroarea and the U.K., I use the shadow rate by Xia and Wu (2018), and for Japan I use Leo Krippner's estimates, available at:
`https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures`

SOEs' currencies. Second, the instrument should be exogenous to each single SOE's fundamentals; and third, in order to have a shock specific to the USD exchange rate, the instrument should also be exogenous to U.S. fundamentals.

Two candidate instruments for SOEs' USD exchange rate shocks arise after these considerations: shocks to the UIP condition of the U.S., and U.S. monetary policy shocks, i.e. changes in the U.S. monetary policy stance unexplained by the Fed's systematic response to economic (and financial) conditions. There are several reasons why these instruments are well suited to proxy exogenous USD exchange rate fluctuations in SOE. On the one hand, there is empirical evidence showing that risk premium shocks to the UIP condition explain the lion's share of the exchange rate variance of the USD against several major currencies (Balakrishnan et al., 2016). Moreover, these shocks also account for a large share of the variation in the real and nominal exchange rates in calibrated and estimated DSGE models (Kollmann, 2002, 2005; Adolfson et al., 2007; Copaciu et al., 2015; Mimir and Sunel, 2019). Finally, it has been shown that introducing these shocks in DSGE models is important to account for the volatility and persistence of exchange rate fluctuations observed empirically (Engel, 2014; Adolfson et al., 2007). On the other hand, U.S. monetary policy shocks can also be used, since, for example, a monetary loosening in the U.S. would cause an overall depreciation of the USD, other things being equal. Moreover, monetary policy surprises are also seen as important drivers of the exchange rate and have been widely used to study exchange rate movements (Engel, 2014).

In my analysis I focus on risk premium shocks to the U.S. UIP condition as the instrument for shocks to the SOEs' exchange rate for the following three reasons. First, the literature on open economy DSGE models uses shocks to the UIP condition as proxies for exchange rate shocks.[20] These can be interpreted as exogenous foreign asset demand shocks, financial shocks affecting foreign exchange market (Engel, 2014; Itskhoki and Mukhin, 2017), or as reflecting a bias in the economic agents' forecast about future exchange rates (Kollmann, 2005). Moreover, in Section 2.5, I use a DSGE model to further study the channel of transmission of exchange rate movements proxied by shocks to the UIP condition. Thus I use U.S. UIP shocks in the LP-IV analysis to ensure that the results are consistent with those in Section

[20] The literature also interprets UIP shocks as shocks to capital flows, see for instance Farhi and Werning (2014).

2.5. Second, since I am mainly interested in the effects of USD exchange rate fluctuation on macroeconomic variables in SOEs and because of the financial nature of UIP shocks, they should not have a first order effect on real variables in the SOE in my sample. Third, a U.S. monetary policy shock may produce misleading results because U.S. monetary policy may not only affect foreign economies through changes in the USD exchange rate, but also through a change in U.S. demand for non U.S. goods and services. Changes in U.S. import demand can have a direct impact on the trade balance of single SOEs.[21] Moreover, the interpretation of the resulting exchange rate appreciation against the USD would not be the same, since using U.S. monetary policy shocks as an instrument, I would be identifying the effects of U.S. monetary policy in SOEs working through exchange rate fluctuations. Furthermore, as I will discuss below, the UIP shocks series proves to be a better instrument for exchange rate shocks in SOEs than U.S. monetary policy shocks, since the F-statistics in its first-stage regression is higher than the one in the first-stage regression using U.S. monetary policy shocks. Summing up, using the UIP shock series as an instrument for USD exchange rate shocks in SOEs allows me to isolate the effects of USD fluctuations from those arising from changes in demand and foreign prices. This is necessary to identify and isolate the channels through which exchange rate fluctuations work.

2.4.2.1 A shock to the U.S. UIP condition

In order to have an instrument that can be used to estimate dynamic causal effects in a LP-IV setting, the instrument η_t must satisfy the following LP-IV conditions (Stock and Watson, 2018):

(i) $E(\epsilon_{1,t}\eta_t') \neq 0$ (relevance);

(ii) $E(\epsilon_{2:n,t}\eta_t') = 0$ (contemporaneous exogeneity);

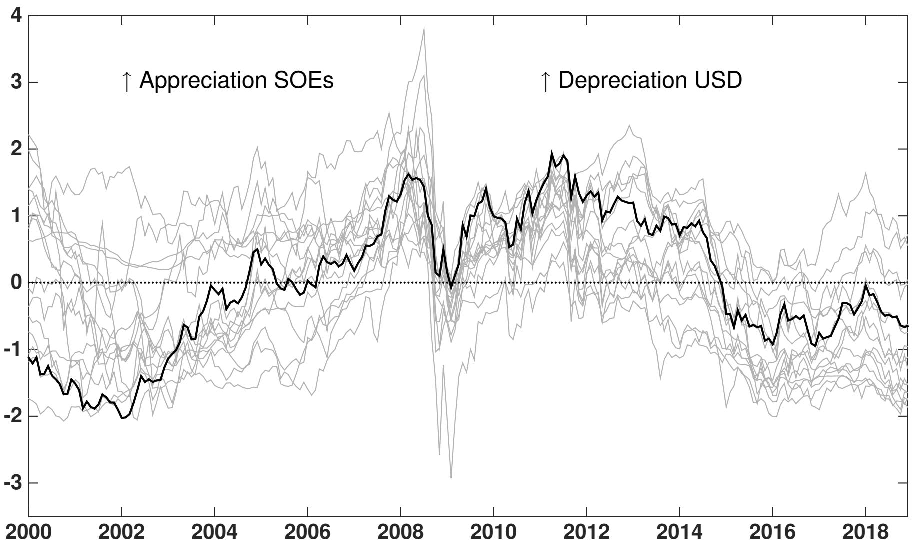
(iii) $E(\epsilon_{t+j}\eta_t') = 0$ for $j \neq 0$ (lead-lag exogeneity);

where $\epsilon_{1,t}$ is the structural shock to be identified and $\epsilon_{2:n,t}$ are all other structural shocks. The relevance condition states that the instrument should be correlated with the structural shock to be identified. Thus, the U.S. UIP shock, which will

[21] However, in a later section, I study to which extent the financial channel affects the transmission of foreign monetary and demand shocks.

be used as an instrument, should be correlated with the exchange rate shock in SOEs. To construct the UIP shock specific to the USD, I use the USD exchange rate against a basket of major currencies. This series is useful because there is a (fairly) high correlation between the effective exchange rate of the USD against major currencies and the exchange rates of the SOEs in my sample, ranging between 0.14 and 0.94, and averaging 0.53.[22] Moreover, Figure 2.4.1 presents the standardized SOEs' exchange rates against the USD (gray lines), and the USD exchange rate against major currencies (black line). These exchange rates co-move considerably, as large depreciations of the USD exchange rate against major economies coincide with appreciations of the SOEs' currencies. The co-movement is especially visible during and after the global financial crisis in 2008. Therefore, exogenous movements to the USD exchange rate against major currencies can also potentially drive individual SOEs' USD exchange rates. In fact, as I will show later, shocks derived from the U.S. UIP condition against major currencies are a valid instrument for SOEs' exchange rate shocks, as the F-statistic is well above 10.

Figure 2.4.1: USD Exchange Rates



Note: The figure shows the standardized monthly nominal effective exchange rate of the USD against major currencies (black line), and the standardized monthly individual exchange rates against the USD of the 17 countries in the sample (gray lines).

[22]Table 2.C.1 in Appendix 2.C shows the correlation coefficients.

Moreover, condition (ii), contemporaneous exogeneity, states that the instrument should be contemporaneously unrelated to all other shocks. In my application this condition is satisfied. On the one hand, to estimate the U.S. risk premium shocks, I use a broad index of currencies and not a bilateral one, say the EUR-USD exchange rate, to make sure that the instrument is specifically related to the USD and not to another currency. Further, I use only major currencies of advanced economies and not an even broader index to minimize the likelihood that the instrument is related to some of the SOEs' fundamentals. Since the currencies of the SOEs in my sample are not used to construct the USD exchange rate against major currencies and assuming that the SOEs in my sample are too small to influence this exchange rate, the constructed UIP shocks are unrelated to SOEs' fundamentals.

On the other hand, as I will explain in detail below, I control for economic and financial conditions in the U.S. and the other major economies, as well as for global conditions. I do so by including interest rates, macroeconomic fundamentals, and financial variables into the estimation of the U.S. risk premium shocks. Thus, these UIP shocks are uncorrelated with other U.S. specific shocks, to shocks specific to the major economies and to global conditions, and therefore satisfy condition (ii).

Finally, condition (iii), lead-lag exogeneity, arises from dynamics and requires that the instrument should be exogenous to past realizations of ϵ and that the instrument should not be correlated to future shocks. To maximize the likelihood that LP-IV condition (iii) is satisfied, I follow Stock and Watson (2018) and include relevant controls in the estimation of the impulse responses using LP-IV.

To estimate the USD risk-premium shock, I start with the risk-premium augmented UIP condition as in Balakrishnan et al. (2016):

$$\mathrm{E_t} e^{us}_{t+k} - e^{us}_t = \beta(i^{us}_{t,t+k} - i^{c}_{t,t+k}) + (rp^{us}_t - rp^{c}_t) \tag{2.1}$$

where e^{us}_t is the USD exchange rate against major currencies, $i^{us}_{t,t+k}$ is the Federal Funds Rate. $i^{c}_{t,t+k}$ is the policy interest rate in country c, rp^{us}_t and rp^{c}_t are country specific risk-premia and β is a coefficient that links the interest rate differentials with exchange rate movements, which I will estimate. Next, I generalize Equation (2.1) to include the USD exchange rate against major currencies, as well as the country specific policy rates in each of the seven major economies in the exchange rate:

$$\mathrm{E_t} e^{us}_{t+k} - e^{us}_t = \beta \sum_{c=1}^{7} (i^{us}_{t,t+k} - i^{c}_{t,t+k}) + (rp^{us}_t - rp^{c}_t), \tag{2.2}$$

after taking first differences, following Kiley (2013), Equation (2.2) becomes:

$$\mathrm{E_t} \Delta e^{us}_{t+k} - \Delta e^{us}_t = \beta \sum_{c=1}^{7} (\Delta i^{us}_{t,t+k} - \Delta i^{c}_{t,t+k}) + \Delta \tilde{RP}_t, \tag{2.3}$$

where $\tilde{RP}_t$ is the risk premia in the U.S. and the other major economies. Following Kiley (2013) and Akinci and Queralto (2018), for sufficiently large k, $\mathrm{E_t}\Delta e^{us}_{t+k} = 0$, and after rearranging Equation (2.3) becomes:

$$\Delta e^{us}_t = -\beta \sum_{c=1}^{7} (\Delta i^{us}_{t,t+k} - \Delta i^{c}_{t,t+k}) - \Delta \tilde{RP}_t.$$

I re-write $\tilde{RP}_t$ to have the following transformed UIP equation:

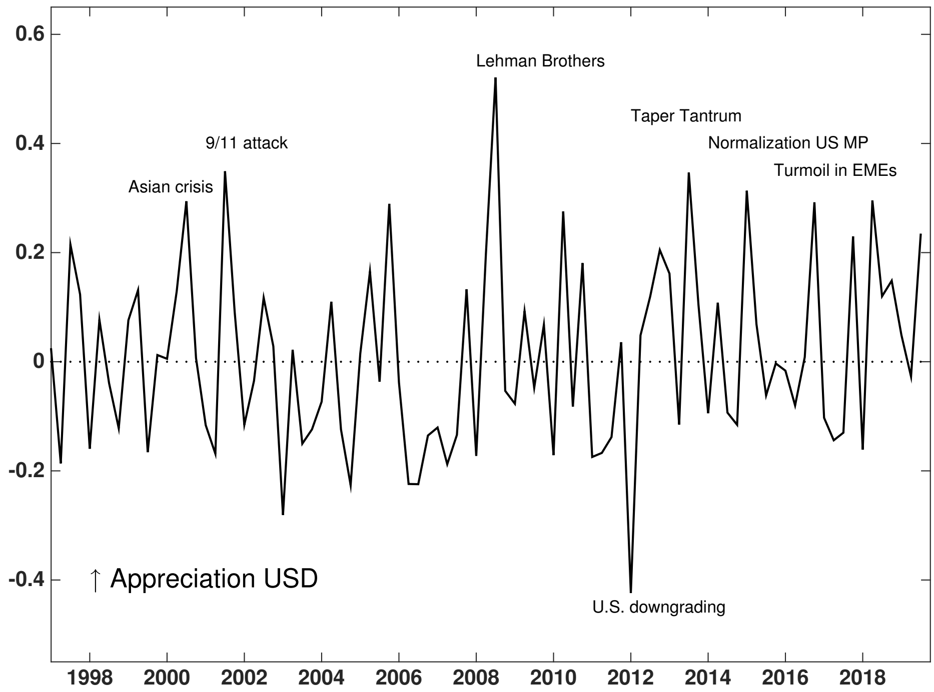
$$\Delta e^{us}_t = -\beta \sum_{c=1}^{7} (\Delta i^{us}_{t,t+k} - \Delta i^{c}_{t,t+k}) - \underbrace{\Delta RP_t}_{\text{endog. risk premium}} - \underbrace{\eta_t}_{\text{UIP shock}},$$

where RP_t is the endogenous risk-premium and η_t is the UIP shock (risk-premium shock). The transformed UIP equation can be estimated as:

$$\Delta e_{us,t} = \beta_0 + \sum_{c=1}^{7} \beta_c (\Delta i^{us}_{t,t+k} - \Delta i^{c}_{t,t+k}) + \sum_{n=1}^{N} \delta_n Z_{nt} + \eta_t, \tag{2.4}$$

where, Z_{nt} is a set of variables to control for the endogenous risk-premia in the U.S. and the major economies, as well as to control for local and global macroeconomic and financial conditions (see below for details). The estimated residuals from Equation (2.4) can be interpreted as USD UIP shocks.[23]

Figure 2.4.2: Estimated U.S. UIP shocks



Note: The figure shows the estimated shocks to the U.S. UIP condition (UIP or risk-premium shocks).

The control variables included in the estimation of Equation (2.4) capture determinants affecting the USD exchange rate against major currencies and affecting global conditions that, in turn, have an impact on SOEs and their bilateral USD exchange rates. To control for endogenous risk premia, and monetary, demand and supply shocks, I include in $Z_{n,t}$ the contemporaneous value and the first lag of GDP growth, inflation rates and policy (shadow) interest rates a for the U.S., and the other

[23] This equation can also be interpreted as a VAR for the U.S. and major economies, where the (nominal effective) exchange rate is ordered last, as it is usual in the SVAR literature that relies on the Cholesky decomposition to identify exogenous exchange rate movements, e.g. An et al. (2014), Hofmann et al. (2017), among others.

major economies, and the lagged first difference of the exchange rate against major currencies. Moreover, I also include the contemporaneous value and the first lag of the first difference of equity prices in the U.S., of commodity prices and the VIX to control for global economic and financial conditions. To avoid overparametrization, I apply a general-to-specific approach and exclude one-by-one all variables for which the estimated coefficient is not significant at the 30 % level.[24] Nevertheless, the regression still includes more than 20 control variables in the final specification. Including a large number of control variables should not be a problem, because this increases the likelihood that the residuals from Equation (2.4) capture UIP shocks and not other determinants of exchange rate fluctuations. In Section 2.4.3, I briefly discuss results using alternative specifications of Equation (2.4).

After estimating Equation (2.4), I use the estimated residual from this regression (the U.S. UIP shocks) $\widehat{\eta}_t$, as the instrument for exchange rate shocks in the SOEs. Figure 2.4.2 shows the estimated USD UIP shocks, where the positive values depict an appreciation of the USD exchange rate, and thus show a negative realization of the shocks from the perspective of the U.S. The large positive and negative realizations of these time series tend to coincide with several events associated with global turmoil or crises in a subset of the SOEs in the sample. For instance, it is well documented that the USD appreciated strongly in the onset of the global financial crisis, during the so-called "Taper Tantrum", or during the recent turmoil in EMEs (Argentina, Turkey, among others). These events are also consistent with 'flight-to-safety' episodes, which are associated with an appreciation of the USD and a depreciation of SOEs' currencies.

2.4.2.2 First-stage regressions

From the considerations above, the U.S. UIP shocks satisfy the LP-IV conditions (i)-(iii), and thus are a good instrument for USD exchange rate movements in SOEs. Additionally, to test the relevance condition formally, I compute the F-statistic of the instrument in the first-stage regression of the LP-IV estimations.

The results from the first stage regressions of Equation (2.5), when real GDP is the dependent variable, are reported in Table 2.4.1. The first column presents

[24]The interest rate differentials, the lagged exchange rate and U.S. variables are always included in the estimation.

the estimation results when the U.S. UIP shock is used as an instrument for the SOEs' exchange rate against the USD, and the second column presents when U.S. monetary policy shocks are used as an instrument.

The results shown in Table 2.4.1 confirm that the U.S. UIP shocks are a strong instrument, since the F-statistic is well above 10. Moreover, the sign of the coefficient is plausible: a positive risk premium shock which results in an overall depreciation of the USD (the effective exchange rate of the USD decreases), appreciates the SOEs' exchange rate.

Table 2.4.1: First stage regressions LP-IV

	First stage regressions instruments
	Baseline: UIP shocks from Equation 2.4
Instrument: U.S. UIP shock $\widehat{\eta}_t$	-0.15***
1st lag Δ bilateral USD exchange rate	0.26***
2nd lag Δ bilateral USD exchange rate	-0.08
1st lag Δ real GDP	0.40**
2nd Δ real GDP	0.07
1st lag Δ CPI	0.36
2nd lag Δ CPI	0.23
1st lag Δ policy interest rate	0.11*
2nd lag Δ policy interest rate	-0.13**
Δ shadow FFR	-0.09*
1st lag Δ shadow FFR	-0.15
Δ VIX	-0.08***
1st lag Δ VIX	-0.03***
Instrument's F-statistic	21.22
Number of observations	1559
Number of countries	17

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

2.4.3 Local Projections Instrumental Variables

With the instrument for exchange rate shocks to SOEs at hand, I compute the impulse responses of several macroeconomic and financial variables using the local projection method by Jordà (2005). Specifically, I use LP-IV (see Stock and Watson, 2018) in a panel fixed effects setting, allowing intercepts to vary by country but constraining other coefficients to be the same.[25] This method's advantage compared to instrumental variable structural VAR (SVAR-IV) is that LP methods are more robust to misspecification (Jordà, 2005; Ramey, 2016). Moreover, Stock and Watson (2018) argue that under invertibility of the SVAR's instantaneous impact matrix of the structural shocks, which can be interpreted as no omitted variables in the SVAR, SVAR-IV and LP-IV are both consistent but the former is more efficient. However, if invertibility fails, LP-IV is consistent while SVAR-IV is not. Therefore, as pointed out by Winne and Peersman (2018), LP-IV can be a solution to omitted variable bias.[26]

2.4.3.1 Empirical results: Macroeconomic and financial effects of exchange rate fluctuations

The strategy to answer the first research question, i.e. *What are the overall macroeconomic and financial effects of USD exchange rate movements in SOEs?*, is straight forward. After identifying an exogenous exchange rate movement in SOEs, I study the effects of a currency appreciation on several macroeconomic and financial indicators using LP-IV. Consider, for example, an appreciation of the domestic currency against the USD. From the considerations in Section 2.3, it can be inferred that an appreciation against the USD should decrease the trade balance through the trade channel, while the effects of the financial channel are more ambiguous. If the empirical results show that an appreciation against the USD increases investment and loosens financial conditions, it can be inferred that the financial channel works through the liability side of the balance sheet. Moreover, if the appreciation

[25] My approach is similar to Lane and Stracca (2017), Auerbach and Gorodnichenko (2012), and Klein (2016).

[26] In a further exercise, I estimate mean-group panel SVAR-IV for a subset of the variables I consider in the LP-IV settings. The results are in line with the local projections, as well as with results in the literature (Hofmann et al., 2017, 2019; Avdjiev et al., 2019). A discussion of this estimation, as well as the impulse responses is available in Appendix 2.B.

is ultimately expansionary, even though the trade balance deteriorates, there is an indication that the financial channel dominates the trade channel on average.

To study this question, I use the following econometric specification, similar to Lane and Stracca (2017). The response of the variable of interest[27] y_t at horizon h can be computing by estimating the following panel regression:

$$y_{i,t+h} - y_{i,t-1} = \alpha_i + \delta_h t + \beta_h \Delta e_{i,t+h} + \Pi_h(L)\Delta y_{i,t-1} + \Xi_h(L)\Delta x_{i,t-1} + u_{i,t+h},, \quad (2.5)$$

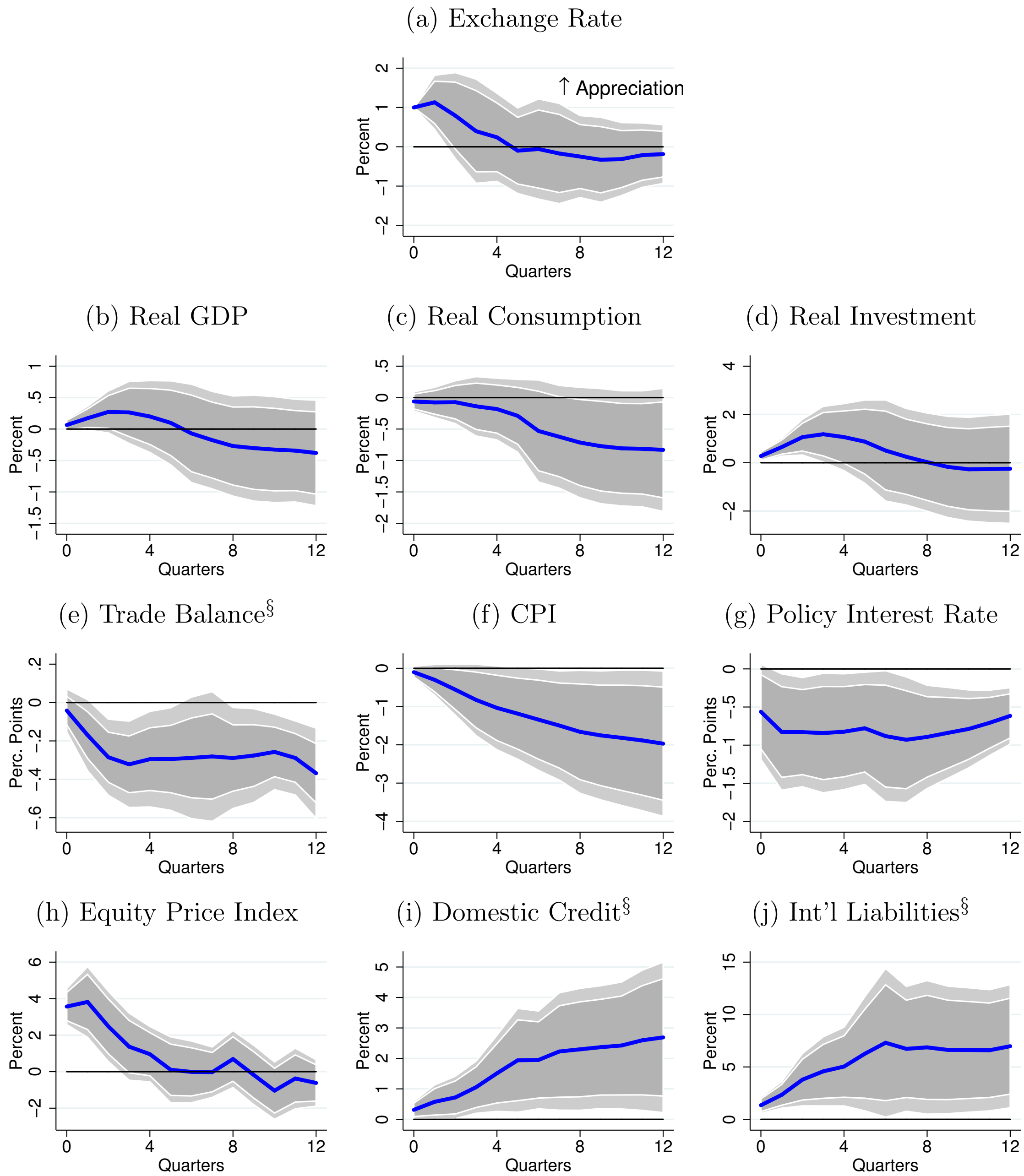
where i and t country and time indices; α_i are country fixed effects, t is a linear trend, $\Pi_h(L)$ and $\Xi_h(L)$ are polynomials in the lag operator, with $L = 2$ in the baseline estimation. $x_{i,t-1}$ is a set of controls such as real GDP, the exchange rate against the USD, price level, interest rate, VIX, and the (shadow) federal funds rate. All variables, except for the trade balance and interest rates, are transformed by taking their natural logarithm. I consider $h = 0, 1, 2, ..., 12$, measuring the effects up to three years ahead. Accordingly, β_h measures the dynamic average cumulative response of the variable of interest at horizon h to an exchange rate movement $e_{i,t+h}$. Following Ben Zeev (2019), I use standard errors that allow arbitrary correlations of the error term across countries and time. As discussed above, the exchange rates against the USD are highly endogenous variables, thus an OLS estimation of Equation (2.5) would lead to inconsistent estimates. Consequently, I instrument the exchange rate $e_{i,t+h}$ with the (cumulative) U.S. UIP shocks $\widehat{\eta}_t$ estimated from the U.S. UIP Equation (2.4). The choice of the variables of interest and controls, as well as the empirical model in general is such that the results are comparable to the ones from the DSGE model in Section 2.5.

Figure 2.4.3 presents the cumulative responses of macroeconomic and financial variables[28] to a one percent appreciation of the SOEs' domestic currencies against the USD. Overall, the results are in line with other empirical evidence in the literature (Hofmann et al., 2019; Avdjiev et al., 2019).

[27] Either real GDP, real private consumption, real gross fixed capital formation, the trade balance as % of GDP, equity prices, capital inflows, the policy interest rate and the price level.

[28] All responses, except for the equity price index, are cumulative.

Figure 2.4.3: Responses to a one percent appreciation of the domestic currency against the USD



Note: The figure shows the estimated impulse responses of several macroeconomic and financial variables to a one percent appreciation of the domestic exchange rates for the panel of 17 SOEs. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
§ as a fraction of GDP.

Real GDP increases by around 0.25 percent after around 3 quarters. The cumulative impulse response of private consumption is not significantly different from zero, while real investment increased significantly by around one percent after three quarters. The trade balance as a share of GDP deteriorates, reaching a trough of 0.4 percentage points; this effect is in line with the implications of the trade channel. CPI also decreases, probably as a result of lower import prices. Moreover, the short-term interest rate also decreases in the SOEs. This is in line with a central bank's response to lower inflation, but also with "fear of floating", i.e. central banks may decrease their short-term interest rates not only to combat falling inflation, but to stabilize the domestic exchange rate after an appreciation. Moreover, equity prices, credit to the private sector and cross-border bank liabilities increase, showing that the appreciation is associated with an overall loosening of financial conditions.

To make sense of these results, it is possible to attribute the responses of the different variables to the effects of the exchange rates through the trade and financial channel. The decrease of the trade balance and CPI inflation is in line with the trade channel. As the domestic currencies appreciate against the USD, the SOEs' trade balances deteriorate on average, and as imports become cheaper, the inflation decreases. Despite the decrease in the trade balance, there is an overall expansionary effect on GDP and its other components. This, in combination with the increases in cross-border liabilities, credit, equity prices and real investment, suggests (i) that the financial channel is expansionary – thus it works through the valuation effects of the liabilities, in line with Hofmann et al. (2019) and Avdjiev et al. (2019) – and (ii) that the financial channel appears to dominate the trade channel.

These results are robust to different specifications of Equation (2.4), i.e. the estimation of the shock, and of Equation (2.5). In Equation (2.4), first I include only contemporaneous variables in the estimation. Second, I include the equity price indices of the U.S. and the other major economies. Third, I add a dummy variable for the last two quarters of 2008 to control for the financial crisis. In all these cases, the estimated UIP shocks remain similar, leading to quantitatively similar results.[29] Finally, turning to the estimation of the LP-IVs, I change the lag lengths in Equations (2.5), and I include other exogenous variables such as commodity prices

[29]Moreover, I also regress the exchange rate against major currencies only on the interest rate differentials. The new shocks series is different from the baseline, and even though the instrument is indeed different, many of the impulse responses remain qualitatively similar. However, the

and U.S. real GDP to control for global demand. The results remain quantitatively robust to those changes. The same is true for the results below.[30]

2.4.3.2 Empirical results: The channels

To examine the drivers of the above results, and to answer the second research question, i.e. *Under which conditions does the financial channel dominate the trade channel?*, I need to be able to disentangle the two channels. As stressed by Avdjiev et al. (2019), the external balance sheet is the key variable that determine the strength of the financial channel. Especially relevant for this paper are the liabilities and assets denominated in USD (as percent of GDP).

Again, consider an appreciation of the SOEs' currencies against the USD. As discussed above, it is possible to infer whether the financial channel dominates the trade channel and whether liabilities or assets in foreign currencies determine the strength of the financial channel by interpreting the impulse response functions. Figure 2.4.3 shows that an appreciation against the USD is overall expansionary since the rise in real GDP is accompanied by a loosening of financial conditions and an increase in real investment. This suggests that the financial channel dominates the trade channel and that the liability side of the external balance sheet is relatively more important than the asset side in determining the effects of the financial channel.

To take a more detailed look at the results, I exploit the heterogeneity of the SOEs in my sample and I split the sample of countries according to economic characteristics that may be relevant for the relative strength of the financial and the trade channels. Specifically, I assess whether the degree of foreign currency exposure (measured by liabilities in USD), assets in USD, trade openness and trade with the U.S. determine the effects of an appreciation against the USD.

I proceed as follows: I use data on liabilities in USD by Bénétrix et al. (2015) and Bénétrix et al. (2020). I calculate the mean level of liabilities in USD for each country over the period in my sample. Then I divide the countries into two groups: countries with high liabilities in USD, which are those that have an average above

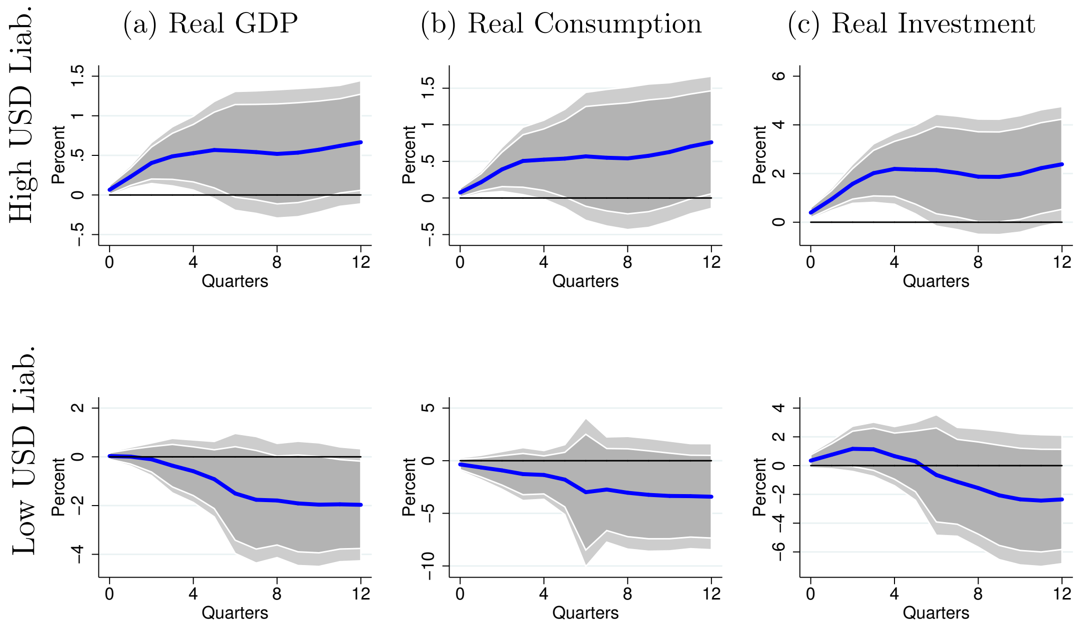
results from this last exercise can be misleading, since the resulting shocks also capture demand and financial shocks in the U.S. and the other advanced economies.

[30]The results from the robustness analysis are in Appendix 2.C. For ease of exposition, I report only the robustness results for GDP.

the median, and countries with low liabilities in USD. I then re-estimate Equation (2.5) for the two groups and assess whether the cumulative responses differ from each other. I do the same for assets in USD, the external vulnerability index and the trade intensity index with the U.S. by Iacoviello and Navarro (2019), and for trade openness. The distributions of liabilities and assets in USD are shown in Figures 2.C.1 and 2.C.2 in Appendix 2.C.

Financial channel - Importance of liabilities in USD

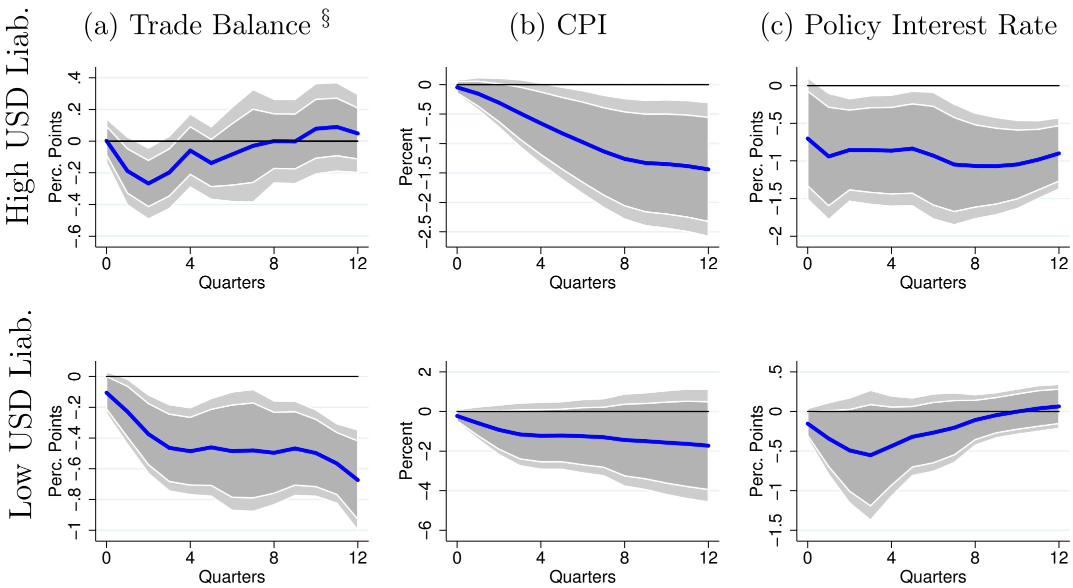
Figure 2.4.4: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD



Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.4.4 shows the cumulative responses of real GDP, real consumption and real investment to a one percent appreciation of the SOEs' domestic currencies against the USD. The first row shows the cumulative responses for the group of SOEs where exposure to liabilities in USD as percent of GDP, is above median, and the second row when USD exposure is below median.

Figure 2.4.5: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD

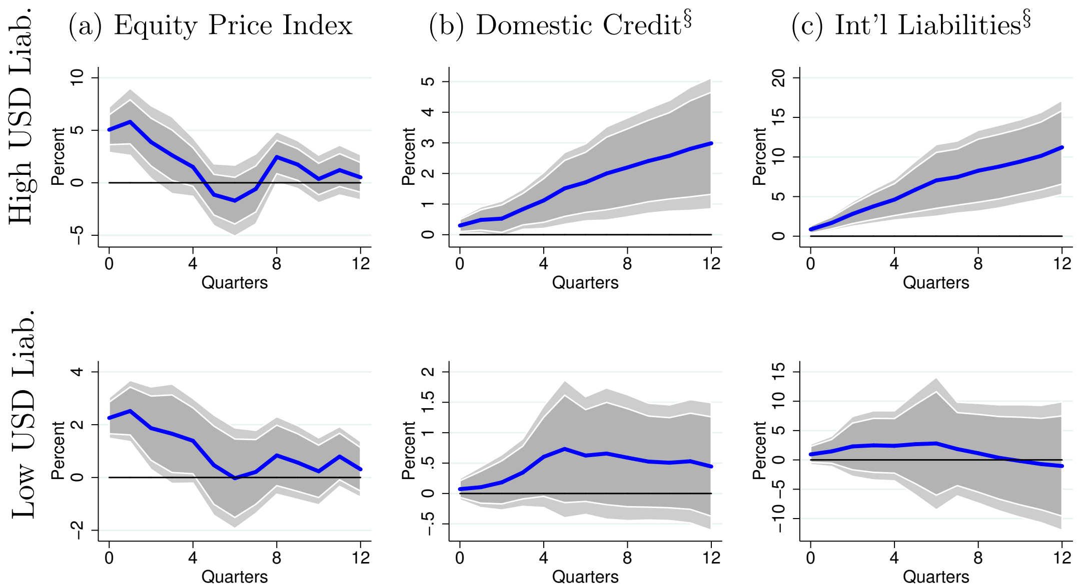


Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
§ as a fraction of GDP.

In the first row, real GDP, real consumption and real investment all increase significantly. The increase in in GDP happens despite a fall in net exports, i.e. the trade balance (see Figure 2.4.5), which is compensated by the strong increase in investment. Meanwhile, the responses for countries with debt in USD below median is different: at first, the response of real GDP and consumption is not significantly different from zero, but the overall cumulative effect is significantly contractionary after 10 quarters, while real investment initially increases slightly significantly.

Figure 2.4.5 shows the cumulative responses of the trade balance, CPI and the policy interest rate. Again the first row presents the results when liabilities in USD are above median and the second row when they are below median. In both cases, the trade balance and CPI decrease significantly, showing the effects from the trade channel. The decrease in net exports is of similar magnitude in both groups for the first three quarters, while the decrease in CPI seems stronger, though less significant, in SOEs with low exposure to USD liabilities. Moreover, the policy interest rate

Figure 2.4.6: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD



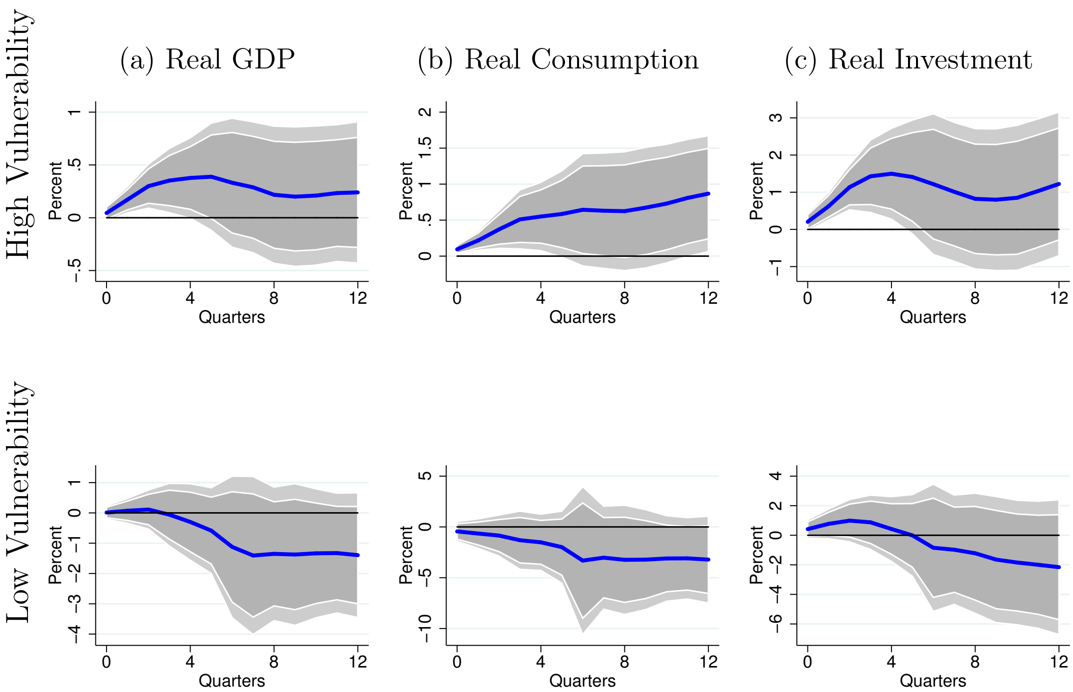
Note: The figure shows the estimated cumulative impulse responses of several financial variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
§ as a fraction of GDP.

decreases in both cases. However, in SOEs with high exposure to USD liabilities the central banks' reaction to the appreciation against the USD is stronger and faster, probably due to the fact that a higher amount of liabilities leads to stronger valuation effects in the balance sheet, thus central banks may be willing to decrease the interest rate more aggressively to combat the appreciation and its valuation effects. When exposure to USD liabilities is below the median, central banks do not decrease the policy rate as quickly, despite the faster decrease of CPI.

Further, Figure 2.4.6 shows the responses of equity prices, credit and cross-border bank liabilities to a one percent appreciation of the domestic exchange rate against the USD. In both groups the equity price index increases significantly, though the rise is stronger for countries with high exposure to USD liabilities. Moreover, credit as well as cross-border liabilities increase significantly when USD exposure is above the median, and they increase insignificantly when they are below the median.

Summing up, these results shed light on the conditions under which the financial channel is strongest. When exposure to USD liabilities is relatively high, an appreciation of the domestic exchange rate against the USD leads – on average – to overall expansionary effects. When exposure to USD liabilities is relatively low, it appears that the trade channel dominates the financial channel, since the overall effect is – on average – slightly contractionary. In the latter case, the decrease in the trade balance appears to cause the decrease of real GDP and real consumption. At the same time, the reaction of the financial variables - equity price index, credit and cross-border banking liabilities- is smaller. Thus, the bottom line of this exercise is that the financial channel seems to dominate the contractionary effects from the trade channel in countries where USD liabilities are relatively high, i.e. where the balance sheet effects of a currency appreciation are potentially more powerful.

Figure 2.4.7: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index

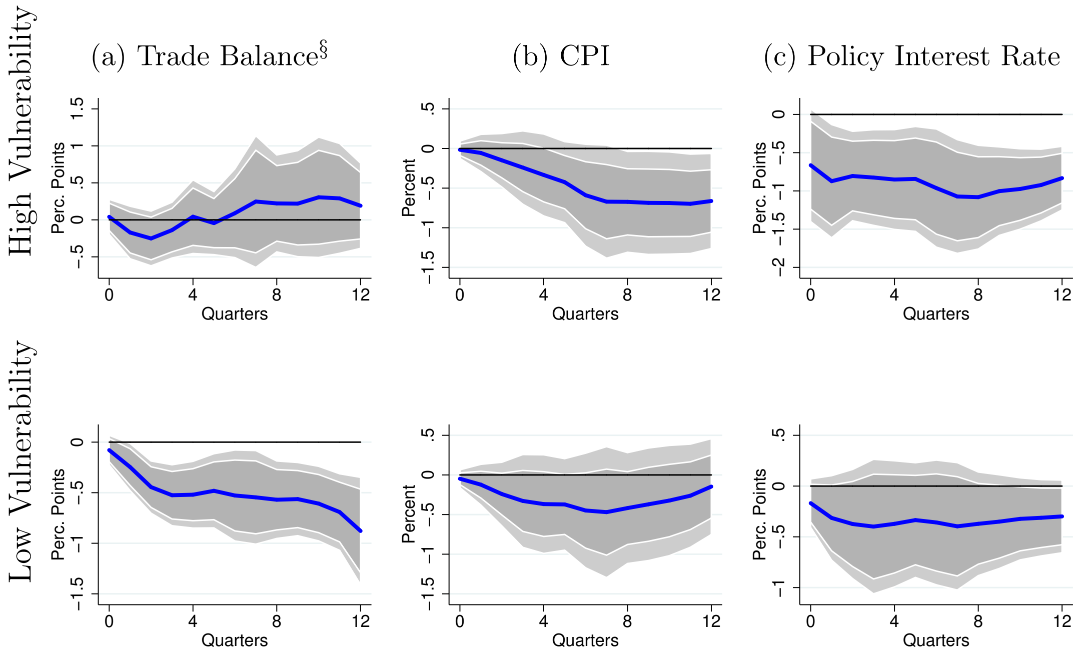


Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

As a robustness check for role of exposures to liabilities denominated in USD, I re-estimate Equation (2.5) dividing the SOEs in my sample according to the external vulnerability index by Iacoviello and Navarro (2019). This index is supposed to reflect a country's financial health. It is constructed as an equally-weighted average of inflation, current account deficit as a share of GDP, external debt minus foreign reserves (as a share of GDP), and foreign exchange reserves.

Generally speaking, the vulnerability index provides a broader picture than just inspecting the role of exposure to USD liabilities, since it also includes other macroeconomic indicators and assets in foreign currency.

Figure 2.4.8: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index

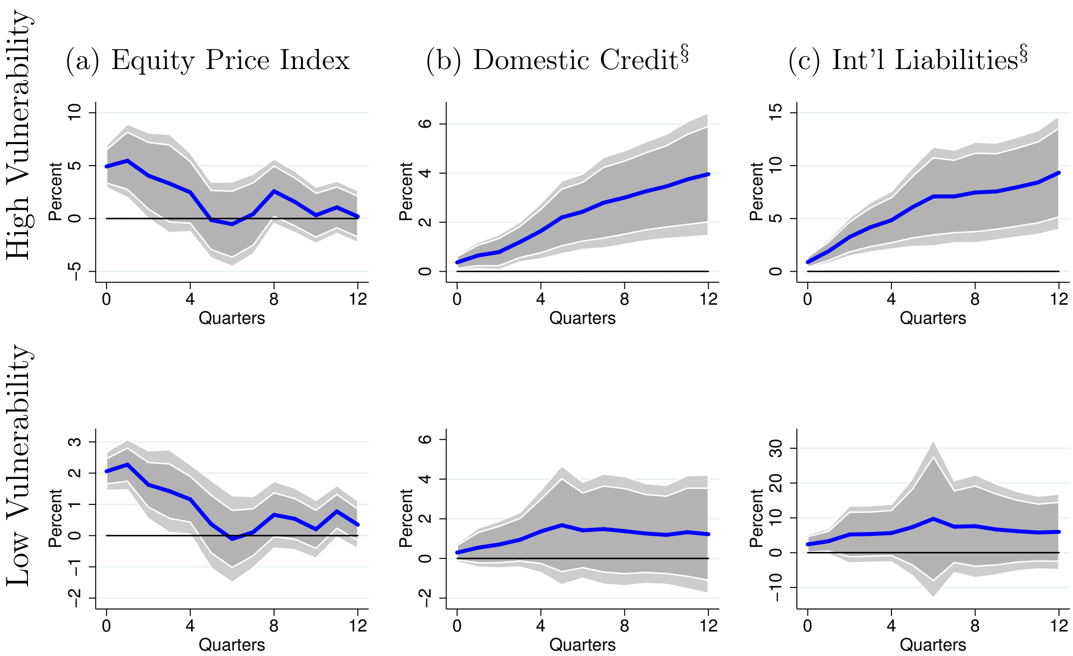


Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

§ as a fraction of GDP.

The impulse responses in Figures 2.4.7 - 2.4.9 are very similar to the ones estimated conditioning on the level of liabilities. This is not surprising because after inspection of the data, the countries in which the vulnerability index is above median coincides very often to the observations where liabilities in USD are above median. The bottom line of this exercise is similar to the one above. When the vulnerability index is relatively high, the financial channel appears to dominate the trade channel, and when the vulnerability index is low, the opposite appears to happen.

Figure 2.4.9: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index



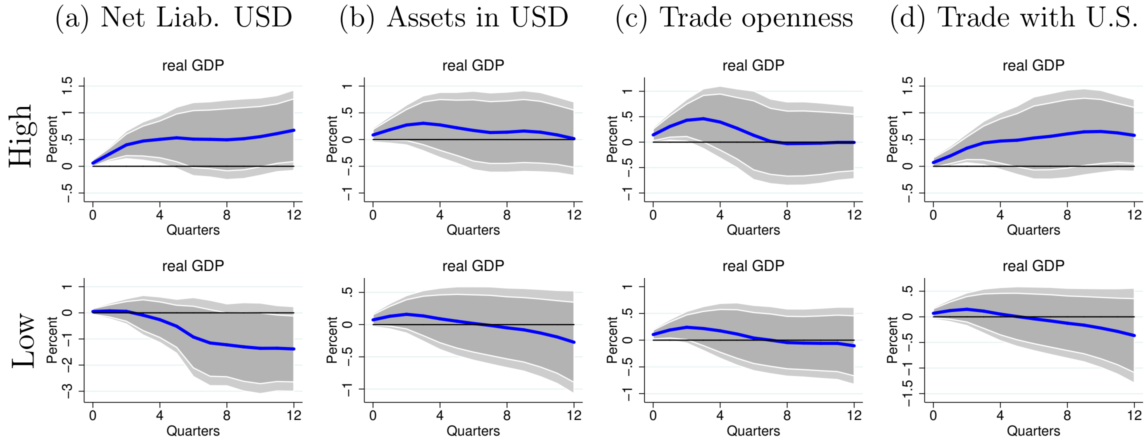
Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
§ as a fraction of GDP.

Assets and the trade channel

Next, to further analyze the financial channel, I again re-estimate Equation (2.5) grouping the SOEs by other indicators related to the financial and trade channel. First, I divide the countries by the amount of net liabilities in USD. Panel (a) in Figure 2.4.10 shows the cumulative response of GDP for countries with high net liabilities in USD (upper figure) and the lower figure shows the response for low net liabilities in USD (lower figure). As in the previous cases, the effect of an appreciation against the USD is expansionary in countries with high net liabilities in USD, while the effect is not significant for countries with low liabilities in USD.

Second, I group the SOEs by the amount assets denominated in USD. If the assets in the external balance sheet matter for the strength and direction of the financial channel, an appreciation of the domestic currency should have a contractionary effect when assets are relatively high. Panel (b) of Figure 2.4.10 show the responses of GDP in two groups, countries with relatively high amount of assets in USD are relatively high (upper figure) and countries with low assets (lower figure). In both cases, the appreciation increases real GDP, but the rise is not significant. The lack of significant difference between the responses in both states seems to suggest that assets in USD are less important for the strength of the financial channel.

Figure 2.4.10: Responses to a one percent appreciation of the domestic currency against the USD by other country characteristics



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the responses when net liabilities in USD are above median (upper figure) and below median (lower figure). Panel (b) shows the responses when assets in USD are above median (upper figure) and below median (lower figure). Panel (c) shows the responses when trade openness is above median (upper figure) and below median (lower figure). Panel (d) shows the responses when trade with the U.S. is above median (upper figure) and below median (lower figure). The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Moreover, I can also use trade openness and the trade intensity with the U.S. to gauge the strength of the trade channel. However, because of the fact that countries have multiple trading partners, the trade weighted exchange rate is more relevant for trade than the bilateral exchange rate against the USD (Hofmann et al., 2019; Kearns and Patel, 2016). This hinders the study the trade channel whit my empirical strategy, since the shock that I identify is related to the SOEs' bilateral exchange rate against the USD. Still, as mentioned above and pointed out by Gopinath (2015), international trade is conducted in very few currencies, and the USD is the most dominant. Thus, despite the limitations described above, I can examine the strength of the trade channel by conditioning the responses on trade openness, and on the trade intensity with the U.S. (Iacoviello and Navarro, 2019). In this sense, if the trade channel dominates the financial channel, an appreciation should be contractionary when trade intensity with the U.S. and overall trade openness are high.

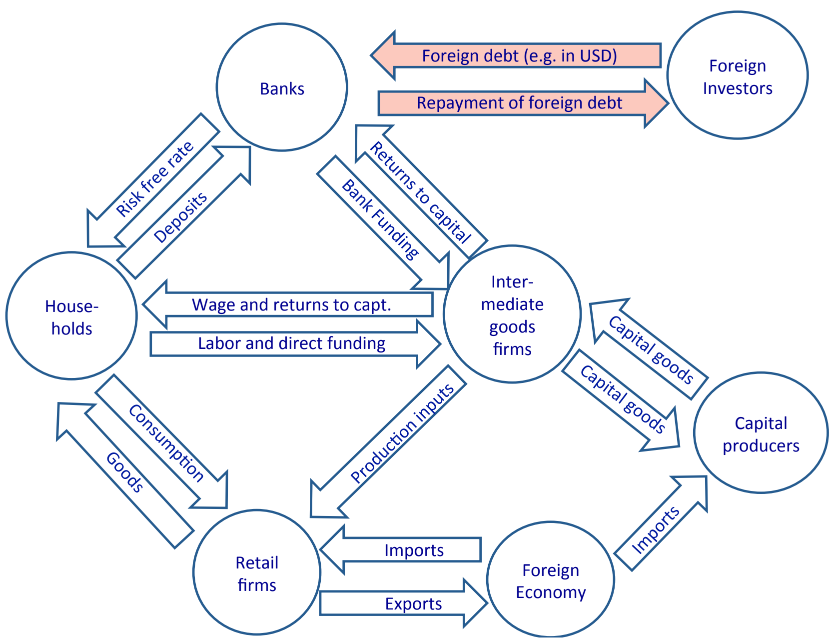
Panels (c) and (d) in Figure 2.4.10 show the impulse responses conditioned on trade openness and trade intensity with the U.S. respectively. Again, real GDP increases after an appreciation, regardless whether the trade openness or trade with the U.S. is above or below the median. These findings suggest that the trade channel may not play a big role when the USD exchange rate moves. These results, in combination with the previous ones in Figures 2.4.4 - 2.4.6, suggest that the strength of the channels depend mostly on the level of liabilities in USD, rather than on variables that could reflect the relevance of trade.

Moreover, the findings in panels (c) and (d) could also indicate that the identified shock, as well as the overall empirical model, may not be suitable to shed light into the trade channel in its full extent. To properly study the trade channel, the identification of country specific exchange rate shocks or a different kind of model may be needed. Therefore, in the next section, I use an estimated DSGE model where the financial and trade channels are explicitly modeled, and where the exchange rate against the USD has a direct impact on exports and imports, and on the external balance sheet of the economy. Thus, the DSGE model may be more appropriate to examine the trade channel, than the LP-IV with the identified instrument.

2.5 A DSGE model for a SOE with liabilities in foreign currency

In Section 2.4, I have shown empirically that exchange rate appreciations can be expansionary depending on the level foreign of currency exposure. In this section I use an open economy DSGE model to deepen the precious analysis, to look closer at financial channel of exchange rates and to have a structural interpretation of the empirical results. Thus, with the estimated DSGE model at hand, I can further address the second research question, *(ii) Under which conditions does the financial channel dominate the trade channel?* and I can examine whether the financial channel of exchange rates has an effect on the transmission of foreign monetary policy shocks, and thus answer the third research question, *(iii) What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE?*

Figure 2.5.1: Structure of the model



I extend a standard New Keynesian small open economy model (see, for instance, Adolfson et al., 2007; Justiniano and Preston, 2010), by including financial frictions where banks can borrow funds in foreign currency (USD) while their assets are denominated in domestic currency, similar to Aoki et al. (2016).[31] This adds a potentially powerful financial channel to the existing trade linkages in standard open economy models. Moreover, the presence of liabilities in USD introduces a feedback mechanism between exchange rate movements and banks' balance sheets, which translates into a loosening of financial conditions when the domestic exchange rate appreciates. Thus, the model is able to take into account the level of USD liabilities as the key determinant of the strength of the financial channel, in line with the empirical evidence presented in Section 2.4.[32]

The model is structured as follows (see Figure 2.5.1). The representative household buys consumption goods from final goods producers, which consist of domestically produced and imported consumption goods. Also, the household sells its labor to the intermediate goods firms. To save, it holds deposits in banks, which are denominated in local currency and yield the risk-free rate. Therefore there is no exchange rate risk for the household, and its deposits are fully insured. The household can also directly finance intermediate goods firms, however, it is less efficient than banks in doing so. Moreover, the investment good is composed of domestic and imported goods. Capital producers produce new investment goods and repair depreciated capital, which they sell to intermediate goods firms. Intermediate goods producers have capital and labor as inputs for production. Furthermore, they receive funding from domestic banks.

Banks have two sources of financing, domestic deposits from the household (denominated in domestic currency), and foreign debt from foreign investors, which is denominated in foreign currency (USD). Since banks' assets are denominated in local currency and part of their liabilities are denominated in USD, they do face exchange rate risk. Moreover, they also face a financial friction similar to the one in Gertler and Karadi (2011), and Gertler and Kiyotaki (2010). Further, I assume that it is easier for banks to run away with foreign funds, which implies the financial friction is more binding for deposits in foreign currency.

[31] Akinci and Queralto (2018) and Mimir and Sunel (2019) build open economy DSGE models with a similar financial friction.

[32] My model does not allow for domestic agents to own assets in USD. However, while the data shows that the countries in my sample do in fact have assets in USD, the results from Section 2.4 suggest that assets do not play a major role in explaining the strength of the financial channel.

2.5.1 Model

I the following section I briefly the key elements of the model, especially those of the financial frictions, the key feature for my analysis.[33]

2.5.1.1 Firms

There is a continuum of domestic monopolistic firms i that produce an intermediate, differentiated good using capital k_t and labor l_t, and subject to an aggregate stationary productivity shock A_t:

$$y_t^H(i) = A_t k_{t-1}(i)^{\alpha} l_t(i)^{1-\alpha} \tag{2.6}$$

where $\alpha \in (0, 1)$.

The monopolistic intermediate goods producers face quadratic price adjustment costs (Rotemberg, 1982). They set their prices $P_t(i)$ to maximize the expected discounted value of profit $\Pi_{t+j}^H(i)$:

$$\max_{P_t^H(i)} \mathrm{E}_0 \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left(\frac{\Pi_{t+j}^H(i)}{P_{t+j}} \right)$$

subject to:

$$\Pi_{t+j}^H(i) = P_{t+j}^H(i) y_{t+j}^H(i) + e_{t+j} P_{t+j}^{H*}(i) ex_{t+j}^H(i) - MC_{t+j} y_{t+j}^H(i) - P_{t+j} \frac{\kappa}{2} \left(\frac{P_{t+j}^H(i)}{P_{t+j-1}^H(i)} - 1 \right)^2$$

and the demand function for good i: $y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\eta} Y_t$. $\Lambda_{t,t+j}$ is the stochastic discount factor. e_{t+j} is the nominal exchange rate, $P_{t+j}^{H*}(i)$ is the price of the domestic good abroad, $ex_{t+j}^H(i)$ is exports of the domestic good, and κ is the price adjustment cost parameter.

[33] For a detailed derivation of this kind of models, I refer to Adolfson et al. (2007), or Mimir and Sunel (2019). See the appendix for the full list of equilibrium equations.

In a symmetric equilibrium, $P_t^H(i) = P_t^H$, so that the solution of the profit maximization yields:

$$p_t^H = \frac{\eta}{\eta-1} mc_t - \frac{\kappa}{\eta-1}\frac{\pi_t^H(\pi_t^H-1)}{y_t^H} + \frac{\kappa}{\eta-1}\mathrm{E_t}\left(\frac{\pi_{t+1}^H(\pi_{t+1}^H-1)}{y_t^H}\right) \tag{2.7}$$

where p_t^H is the price level of domestically produced goods divided by the CPI price level, π_t^H is the inflation rate of the domestically produced goods, and π_t is the gross CPI inflation rate in period t. Real marginal costs, from the cost minimization problem, are:

$$mc_t = \tilde{\xi}_t^c \frac{1}{A_t}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\left(\frac{Z_t}{\alpha}\right)^{\alpha} \tag{2.8}$$

Z_t and w_t are the real rental price of capital and the real wage respectively, and $\tilde{\xi}_t^c$ is a cost-push shock.

Similarly, the solution of the imported goods firms' problem is given by:

$$p_t^F = \frac{\eta}{\eta-1} s_t - \frac{\kappa}{\eta-1}\frac{\pi_t^F(\pi_t^F-1)}{y_t^F} + \frac{\kappa}{\eta-1}\mathrm{E_t}\left(\frac{\pi_{t+1}^F(\pi_{t+1}^F-1)}{y_t^F}\right)$$

where where p_t^F is the price level of imported goods divided by the CPI price level, π_t^F is the inflation rate of the imported goods, and s_t is the real exchange rate.

These intermediate goods are combined into final domestic and imported goods through the Dixit-Stiglitz aggregator:

$$y_t^H = \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}} \qquad y_t^F = \left[\int_0^1 y_t^F(i)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}$$

with $\eta > 1$.

2.5.1.2 Households

The domestic representative household consists of a continuum of bankers and workers. Each banker manages a bank until it retires with probability $(1 - \sigma)$. After retirement, the bankers transfer their remaining net worth to the household, and are replaced by the same amount of bankers. Each new banker receives a fraction of total assets as start-up funds. It is also assumed that bankers are more efficient than workers in providing funds to firms since workers pay extra management costs. Moreover, besides investing directly in firms, workers can deposit currency at the banks, but cannot hold directly foreign debt nor borrow from foreigners.

The representative household chooses consumption c_t, labor supply l_t, direct capital ownership k_t^h, and bank deposits d_t to maximize the expected utility:

$$\mathrm{E}_0 \left[\tilde{\xi}_t^g \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - h_c c_{t-1})^{1-\sigma_c} - 1}{1 - \sigma_c} - \frac{\zeta_0}{1+\zeta} l_t^{1+\zeta} \right) \right] \tag{2.9}$$

subject to the budget constraint:

$$c_t + q_t k_t^h + \chi(k_t^h) + d_t = w_t l_t + \Pi_t + (Z_t + (1-\delta) q_t) k_{t-1}^h + R_{t-1} d_{t-1}, \tag{2.10}$$

where $h_c \in (0, 1]$ is external consumption habit, $\sigma_c > 1$ is the intertemporal elasticity of substitution, $\zeta > 0$ is the inverse Frisch elasticity of labor supply, ζ_0 is the utility weight of labor, q_t is equity price, d_t the real value of deposits, $\chi(k_t^h)$ represents the cost disadvantage of the households in providing funding firms, R_t is the gross real interest rate, Π_t is profits, $\beta \in (0, 1)$ is the discount factor and $\tilde{\xi}_t^g$ is a preference shock.

Moreover, the consumption good is an aggregate of domestically produced and imported goods, as in Galí and Monacelli (2005) or Adolfson et al. (2007):

$$c_t = \left[\omega^{\frac{1}{\gamma_c}} \left(c_t^H \right)^{\frac{\gamma_c - 1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}} \left(c_t^F \right)^{\frac{\gamma_c - 1}{\gamma_c}} \right]^{\frac{\gamma_c}{\gamma_c - 1}},$$

where $\omega \in (0, 1)$ is the home bias parameter, and $\gamma_c > 0$ is the elasticity of substitution between domestic and imported goods.

2.5.1.3 Banks

As stated above, banks fund intermediate goods firms, i.e. buy equity in intermediate goods firms. Banks finance their operations by accepting deposits from domestic households, by borrowing from abroad and by using their own net worth. Each banker retires at some point and brings back its net worth to the household. To motivate a limit on the bank's ability to raise funds, I follow Aoki et al. (2016), who introduce a moral hazard problem similar to the one in Gertler and Karadi (2011) and Gertler and Kiyotaki (2010). After raising funds, the bank decides whether to operate honestly or divert funds. When bankers decide to divert funds, creditors will force them to bankruptcy and bankers will loose the franchise completely. Thus, the bankers' decision of diverting funds or to act honestly depends on the value of future dividends that they would get if she is honest, and on the value of the assets that could be diverted. The objective of the banks is the expected present value of future net worth n_{t+j}:

$$V_t = \mathrm{E}_0 \left[\sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} (1-\sigma) n_{t+j} \right], \tag{2.11}$$

where $\sigma^{j-1}(1-\sigma)$ is the probability of retirement. The aggregate flow of funds constraint of banks is given by:

$$n_t = (Z_t + (1-\delta)Q_t)k^b_{t-1} - R_{t-1}d_{t-1} - s_t R^*_{t-1} d^*_{t-1}, \tag{2.12}$$

where k^b_t, d_t, R^*_t and d^*_t are the individual bank's capital holdings, domestic deposits, the foreign interest rate and foreign debt.

Aoki et al. (2016) assume that the ability of banks to divert funds depends on the source of the funds. Banks can divert the fraction of assets given by:

$$\Theta(x_t) = \theta \left(1 + \frac{\gamma}{2} x_t^2 \right), \tag{2.13}$$

where $\theta > 0$ is the severity of the banks' moral hazard,

$$x_t = \frac{s_t d_t^*}{q_t k_t^b} \tag{2.14}$$

is the fraction of assets financed by foreign borrowing, and $\gamma > 0$ is the degree of home bias in funding. A positive γ means that banks can divert a larger fraction of assets when they raise foreign funds. Since banks evaluate whether they divert funds by comparing the value of their franchise with the value of divertable funds, the incentive constraint of the bank is given by:

$$V_t \geq \Theta(x_t) q_t k_t^b$$

Thus, banks choose k_t^b, d_t and d_t^* to maximize its value:

$$V_t = \mathrm{E_t}\left[\Lambda_{t,t+1}\left[(1-\sigma)n_{t+1} + \sigma V_{t+1}\right]\right].$$

Following Aoki et al. (2016), the value function can be re-written as:

$$\psi_t \equiv \frac{V_t}{n_t} = \mathrm{E_t}\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\frac{n_{t+1}}{n_t}\right],$$

where ψ_t is Tobin's q ratio of banks. After defining the leverage multiple as $\phi_t = \frac{q_t k_t}{n_t}$, and using the definition of the balance sheet, the flow of funds constraint can be written as:

$$\frac{n_{t+1}}{n_t} = \left[\frac{Z_{t+1} + (1-\delta)q_{t+1}}{q_t} - R_{t+1}\right]\phi_t + \left[R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \Psi_t\right]\phi_t x_t + R_{t+1}.$$

Thus, banks choose ϕ_t and x_t to maximize Tobin's q ratio:

$$\psi_t = \max_{\phi_t, x_t}\left(\mu_t \phi_t + \mu_t^* \phi_t x_t + \nu_t\right),$$

subject to the incentive constraint:

$$V_t \geq \Theta(x_t)\phi_t = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)\phi_t$$

The UIP condition in this model arises from the banks' problem and is given by:

$$\mu_t^* = \mathrm{E_t}\left[\Omega_{t+1}\left(R_{t+1} - \frac{e_{t+1}}{e_t}R_{t+1}^*\Psi_t\right)\right], \tag{2.15}$$

where μ_t^* is the cost advantage of foreign currency debt over domestic deposits, and the banks' stochastic discount factor is: $\mathrm{E_t}\Omega_{t+1} = \mathrm{E_t}\Lambda_{t,t+1}(1 - \sigma + \sigma\psi_{t+1})$. The risk premium is given by:

$$\Psi_t = \exp\left(\psi_1 \hat{d}_{t+1}^*\right)\psi_t,$$

where $\log(\psi_{t+1}) = \rho_\psi \log(\psi_t) + \xi_{t+1}^\psi$, and ξ_{t+1}^ψ is the risk premium shock (UIP shock).

Moreover, μ_t, the excess return on capital over home deposit, and ν_t are defined as:

$$\mu_t = \mathrm{E_t}\left[\Omega_{t+1}\left(\frac{Z_{t+1} + (1-\delta)q_{t+1}}{q_t} - R_{t+1}\right)\right], \tag{2.16}$$

$$\nu_t = \mathrm{E_t}\left[\Omega_{t+1}R_{t+1}\right] \tag{2.17}$$

In cases, where μ_t and μ_t^* are positive, the incentive constraint is binding and the solution of the banks' problem is given by:

$$\phi_t = \frac{\nu_t}{\Theta(x_t) - (\mu_t + \mu_t^* x_t)} \tag{2.18}$$

$$\psi_t = \Theta(x_t)\phi_t \tag{2.19}$$

$$x_t = \frac{1}{\tilde{\mu_t^*}}\left(-1 + \sqrt{1 + \frac{2}{\gamma}\tilde{\mu_t^*}^2}\right), \tag{2.20}$$

with $\tilde{\mu_t^*} \equiv \frac{\mu_t^*}{\mu_t}$.

Thus, the leverage ratio is a decreasing function of θ and and increasing function of μ_t and μ_t^*; and x_t is an increasing function of $\tilde{\mu_t^*}$. Intuitively, this means that if $\tilde{\mu_t^*}$ is large, banks will raise more deposits from foreign investors.

2.5.1.4 Capital producers

Capital producers operate in a perfectly competitive environment. They repair the depreciated capital that they acquire from intermediate goods firms and purchase investment goods, which they transform into capital. Thereafter, they sell their produced capital goods to intermediate goods firms at price q_t.

Capital producers use an investment good that is composed of domestic and imported final goods:

$$i_t = \left[\omega^{\frac{1}{\gamma_c}}\left(i_t^H\right)^{\frac{\gamma_c - 1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}}\left(i_t^F\right)^{\frac{\gamma_c - 1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c - 1}}.$$

The aggregate capital stock accumulates through investment i_t

$$k_{t+1} = \tilde{\xi}_t^i\left(1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right)i_t + (1-\delta)k_t, \tag{2.21}$$

where $\Phi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$ represents investment adjustment costs, $\delta \in (0,1)$ is the depreciation rate, and $\tilde{\xi}_t^I$ is a stationary investment efficiency shock.

2.5.1.5 Monetary policy

The policy maker in the domestic economy sets the nominal interest rate following a Taylor rule, which responds to inflation and to deviations of GDP from its steady state. In an alternative specification, I allow the policy maker to also respond to changes in the nominal exchange rate. The Taylor rule is given by:

$$r_t^n - r^n = (1-\rho_i)\left[\omega_i(\pi_t - \pi) + \omega_y(gdp_t - gdp) + \omega_e(\Delta e_t)\right] + \rho_i(r_{t-1}^n - r^n) + \xi_t^{MP} \quad (2.22)$$

where r_t^n is the nominal interest rate and $\xi_t^{MP} \sim \mathcal{N}(0, \sigma_i)$ is the domestic monetary policy shock. In the baseline specification I assume $\omega_e = 0$.

2.5.1.6 Market clearing, foreign economy and exogenous disturbances

Equilibrium in the goods market of domestically produced goods requires:

$$y_t^H = c_t^H + i_t^H + g_t^H + ex_t^H + \left(p_t^H\right)^{-\gamma} \frac{\kappa}{2}\left(\pi_t \frac{p_t^H}{p_{t-1}^H} - 1\right)^2 + \chi(k_t^h) \quad (2.23)$$

where g_t^H is government consumption. Following Aoki et al. (2016), exports are a function of the real exchange rate and foreign output:

$$ex_t = \left(s_t^{\varphi} y_t^*\right)^{(\rho_{ex})} \left(ex_{t-1}\right)^{1-\rho_{ex}} \quad (2.24)$$

and φ is the elasticity of export demand.

Similarly, equilibrium in the imported goods market is given by:

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-\gamma} \frac{\kappa}{2}\left(\pi_t \frac{p_t^F}{p_{t-1}^F} - 1\right)^2 \quad (2.25)$$

Moreover, real GDP, net of adjustment costs, is given by:

$$gdp_t = c_t^H + i_t^H + g_t^H + ex_t^H \quad (2.26)$$

Aggregate capital is $k_t = k_t^h + k_t^b$, and aggregate net worth of banks evolves as:

$$n_t = (\sigma + \xi)(Z_t + (1 - \delta))k_{t-1}^b - \sigma R_t d_{t-1} - \sigma s_t R_{t-1}^* d_{t-1}^*. \tag{2.27}$$

where ξ are the new bankers' start-up funds, k_t^b is the capital owned by the banks, and d_t^* is net foreign debt (foreign investors' deposits in the domestic banks). Finally, the net financial position of the domestic economy evolves as:

$$d_t^* = R_{t-1}^* d_{t-1}^* + y_t^F - \frac{1}{s_t} ex_t. \tag{2.28}$$

Following Copaciu et al. (2016), the foreign economy, which is exogenous to the domestic one, consists of a simple closed economy New Keynesian model subject to a demand shock, a cost-push shock, and a monetary policy shock. The former two shocks follow AR(1) processes, while the latter is an i.i.d. process.

The domestic economy is subject to the UIP-risk premium shock and to five other purely domestic shocks: stationary technology shock, stationary investment efficiency shock, cost push shock, preference shock and monetary policy shock. The UIP, technology, investment efficiency, cost push and preference shocks follow an AR(1) process, while the monetary policy shock is an i.i.d. processes. In total, the model is subject to nine different shocks, six of them affect the domestic economy directly

2.5.2 Estimation of the DSGE model

The model is estimated using Bayesian techniques for Brazilian and Polish data.[34] Brazil is one of the countries with highest amount of foreign liabilities in USD in my sample. Moreover, Brazil is a relatively closed economy. On the other hand, Poland is one of the countries with lowest liabilities in USD in my sample, and at

[34] The estimates of the foreign asset and liability positions of Hungary are one of the few that are not similar or identical in Bénétrix et al. (2015) and Bénétrix et al. (2020). This is why in this version of the paper, I present the results for Poland. The conclusions and implications drawn remain the same.

the same time it is very open to trade.[35] The sample period for the estimation is 1997Q1 - 2019Q2.[36] I use nine observable time series: real GDP growth, CPI inflation, real consumption growth, real gross fixed capital formation growth, the nominal policy interest rate, the nominal exchange rate against the USD, U.S. real GDP growth, U.S. CPI inflation, and the Federal Funds Rate.[37] I remove the mean of all the observable variables. Moreover, similar to Christiano et al. (2011), I allow for measurement errors in all the observables, except for the nominal interest rates (both in the domestic economy and in the U.S.). I calibrate the variance of the measurement errors for all the variables to be 10% of the standard deviation of the time series, except for inflation, for which I calibrate it to be 25%, again, following Christiano et al. (2011).

Table 2.5.1 presents the calibrated parameters. The discount factor is calibrated to match the mean policy interest rates in Brazil and Poland in the sample period. Further, I set the steady state for the foreign interest rate at 1.2% to match the mean of the (shadow) FFR. The parameter ω was calibrated so that trade openness in Brazil is 24% and in Poland 74.5% of domestic GDP, matching the data. The parameters θ, γ and ξ are calibrated so that the leverage ratio in Brazil equals 8.25 and in Poland 8.5, the foreign debt denominated in USD in Brazil amounts to 29% of GDP and in Poland to 9%, and the spread between return on bank assets and deposits equals 2 percentage points in both cases. These four key parameters in the model are calibrated and not estimated because the data used for estimation does not allow for their identification. Moreover, I calibrate $\rho_{ex} = 0.2$, which is close to the value in Mimir and Sunel (2019) and is consistent with OLS estimates of a linearized version of Equation (2.24). I calibrate all other parameters following Aoki et al. (2016) and Mimir and Sunel (2019).

[35] Figure 2.C.3 in Appendix 2.C shows a scatterplot for USD liabilities and trade openness.

[36] I estimate the model with data of all other countries in my sample, except for Israel and the Czech Republic. The results and conclusions drawn from those exercises are very similar to the ones I present in this section. The responses of real GDP to a 100 basis points decrease in risk premium (UIP shock) for all fifteen countries are in Appendix 2.D.

[37] For the period when the Federal Funds Rate was at the zero lower bound, I use the shadow rate by Xia and Wu (2018). Wu and Zhang (2019) also estimate a DSGE model using the shadow rate and show that this is equivalent to taking into account unconventional monetary policies in the model.

Table 2.5.1: Calibrated parameters and steady state targets

Parameter	Value - Brazil	Value - Poland	Description	Target
β	0.985	0.985	Discount factor (quarterly)	mean policy rate
γ_c	0.5	0.5	Elastic. H-F. goods	Mimir & Sunel (2019)
$\varkappa$	0.0015	0.0015	Cost of direct finance	Aoki et al. (2016)
α	0.4	0.4	Cost share of capital	Mimir & Sunel (2019)
δ	0.02	0.02	Depreciation rate	Aoki et al. (2016)
ψ_1	0.01	0.01	For. debt elastic. prem.	literature
η	11	11	Elasticity of demand	Mimir & Sunel (2019)
ρ_{ex}	0.2	0.2	Foreign output in exports	Literature and estim.
ω	0.85	0.625	Home bias in c_t and i_t	Trade openness
σ	0.923	0.938	Survival probability	Aoki et al. (2016)
ξ	1.2×10^{-4}	1.2×10^{-4}	Endowment new bankers	ϕ_t, x_t & spread
θ	0.49	0.44	Divertable assets	ϕ_t, x_t & spread
γ	5.34	20.39	Home bias in funding	ϕ_t, x_t & spread
ω_e	0.10	——	TR coefficient exch. rate	——
π_t	1	1	Gross inflation	Mimir & Sunel (2019)
x_t	0.29	0.09	Portion of the banks liab. in USD	Liab. in USD as % of all liab.
ϕ_t	8.25	8.5	Leverage ratio	World Bank data
s_t	0.02	0.02	Spread bank assets & deposits	Aoki et al. (2016)
R_t^*	1.012	1.012	Foreign interest rate/(shadow) FFR	mean

Table 2.5.2 present the priors of the estimated parameters of the model. I chose the priors following the literature on the estimation of open economy DSGE models with data for SOEs (see, for instance, Justiniano and Preston, 2010; García-Cicco et al., 2014; Copaciu et al., 2015). Further, I scale the standard deviations of the shocks such that they are of similar order of magnitude (Christiano et al., 2011). Finally, I obtain the estimation results using a Metropolis-Hastings chain with 200,000 draws after a burn in of 50,000 and an acceptance ratio of around 0.30 for Brazil and 0.20 for Poland. The estimated parameters are also shown in Table 2.5.2. In general, the posterior means seem to be plausible, and are in line with the broad literature on estimated DSGE models. Similarly to García-Cicco et al. (2014), the posterior mean of the investment adjustment cost parameter in both countries is close to 1, which would be on the low end of this parameter's estimates in the literature.

Table 2.5.2: Priors and posteriors

			Prior		Posterior Brazil		Posterior Poland	
Para.	Description	Dist.	Mean	s.d.	Mean	s.d.	Mean	s.d.
σ_c	Intertemp. elastic. of subst.	gamma	1.2	0.4	0.81	0.16	1.17	0.29
ζ	Inv. Frisch elas.	norm.	5	0.5	4.39	0.58	5.15	0.61
h_c	Habit in consumption	beta	0.7	0.1	0.79	0.03	0.71	0.05
κ	Inv. slope PC	norm.	150	20	216.6	16.3	196.8	25.1
φ	Elas. exp. dem.	norm.	1	0.05	0.87	0.02	1.11	0.06
κ_I	Inv. adj. cost	norm.	3	0.5	0.9	0.16	1.16	0.25
ω_π	TR coeff. inf.	gamma	1.5	0.15	1.20	0.05	1.13	0.1
$\omega_{\Delta y}$	TR coeff. growth	gamma	0.5	0.15	0.53	0.12	0.22	0.07
$\omega*_\pi$	U.S. TR coeff. inf.	gamma	1.5	0.15	1.29	0.10	1.31	0.09
$\omega*_{\Delta y}$	U.S. TR coeff. growth	gamma	0.5	0.15	0.18	0.03	0.22	0.04
$\gamma*_{\Delta y}$	Elast. of subst. U.S.	gamma	1.2	0.4	2.65	0.45	2.91	0.62
κ_{π^*}	Inv. slope PC U.S.	norm.	150	50	149.3	44.85	163.1	46.21
ρ_i	Autoreg. dom. TR	beta	0.7	0.1	0.47	0.04	0.58	0.02
ρ_A	Autoreg. techn. shock	beta	0.7	0.1	0.66	0.10	0.33	0.07
ρ_I	Autoreg. inv. effi. shock	beta	0.7	0.1	0.72	0.08	0.89	0.06
ρ_ψ	Autoreg. risk prem. shock	beta	0.7	0.1	0.92	0.02	0.91	0.02
ρ_{cp}	Autoreg. cost push shock	beta	0.7	0.1	0.90	0.03	0.93	0.02
ρ_g	Autoreg. pref. shock	beta	0.7	0.1	0.25	0.07	0.38	0.04
ρ_{y*}	Autoreg. for. dem. shock	beta	0.7	0.1	0.87	0.02	0.92	0.03
$\rho_{\pi*}$	Autoreg. for. inf. shock	beta	0.7	0.1	0.39	0.08	0.41	0.02
ρ_{i*}	Autoreg. for. MP shoc	beta	0.7	0.1	0.88	0.01	0.87	0.01
$\sigma_i \times 10$	s.d. dom. MP shock	inv. gam.	0.1	2	0.12	0.02	0.19	0.02
$\sigma_A \times 10$	s.d. stat. tech. shock	inv. gam.	0.1	2	0.07	0.02	0.16	0.01
σ_I	s.d. stat. inv. effi. shock	inv. gam.	0.1	2	0.46	0.10	0.66	0.12
$\sigma_\psi \times 10$	s.d. risk prem. shock	inv. gam.	0.1	2	0.08	0.02	0.11	0.01
σ_{cp}	s.d. cost push shock	inv. gam.	0.1	2	0.07	0.01	0.06	0.01
σ_g	s.d. pref. shock	inv. gam.	0.1	2	0.04	0.01	0.14	0.02
$\sigma_{y*} \times 10$	s.d. for. dem. shock	inv. gam.	0.1	2	0.02	0.002	0.16	0.03
$\sigma_{\pi*} \times 10$	s.d. for. infl. shock	inv. gam.	0.1	2	0.04	0.01	0.11	0.01
$\sigma_{i*} \times 100$	s.d. for. MP shock	inv. gam.	0.1	2	0.14	0.01	0.16	0.01

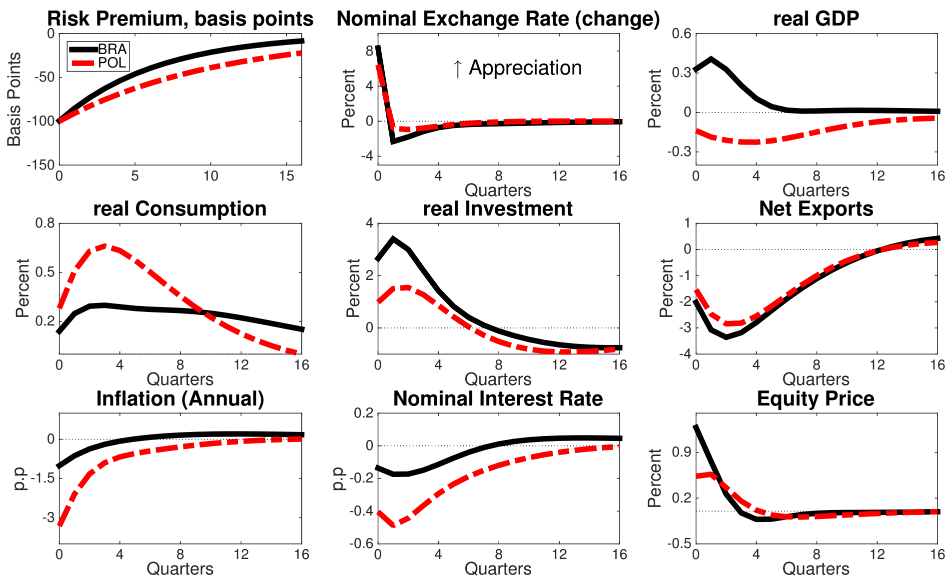
2.5.2.1 The UIP shock

Impulse response analysis - UIP shock

To study the effects of an appreciation of the exchange rate, and again address the first and second research questions of this paper, I follow Copaciu et al. (2015) and analyze the impulse responses of the relevant variables to a shock to the UIP condition.

Figure 2.5.2 shows the impulse responses to a 100 basis points[38] decrease in the risk premium for Brazil (black line) and Poland (red line). The decrease in the risk premium leads to a nominal exchange rate appreciation in both countries, but the appreciation is larger in Brazil, which has more liabilities in USD than Poland. Moreover, this appreciation leads to a decrease in net exports of roughly the same magnitude in both countries, relative to their respective steady state values. At the same time, inflation decreases in both cases, as expected after an appreciation. The decrease, however, is more pronounced in Poland, since higher trade opennes means that a higher share of the CPI is due to foreign prices. These responses are in line with the implications of the trade channel. The central bank reacts to the decrease in inflation by lowering the interest rate. Again, the responses in Poland are of a larger magnitude.

Figure 2.5.2: Impulse responses from a 100 basis points decrease in the risk premium



The appreciation also leads to an increase in equity prices in both countries. In this case, the response in Brazil, the economy with more liabilities in USD, is much stronger. Investment also rises in Brazil by a significantly higher amount than

[38]I study the response to a 100 basis points decrease in the risk premium rather than a one percent appreciation of the exchange rate because the UIP shock affects specifically the risk premium. Studying a one percent appreciation would have the similar implications.

in Poland. In Brazil, high foreign currency exposure creates a positive feedback effect between the exchange rate appreciation and the banks' balance sheet, which translates into more favorable financial conditions for investment. The response of consumption, in contrast, is much stronger in Poland. Again, this is probably due to the higher amount of foreign goods in the consumption basket. Overall, the appreciation turns out to be expansionary in Brazil and contractionary in Poland, as real GDP increases in the former and decreases in the latter.

The appreciation's radically different outcomes in Brazil and Poland cannot be accounted by the rather small discrepancies in all estimated parameters. Therefore, the different results must reflect the different levels of liabilities denominated in USD and of trade openness. In Brazil, the financial channel clearly dominates the trade channel, while in Poland the opposite is true.

The bottom line of this exercise is that an appreciation due to a decrease in the risk premium could be expansionary when foreign liabilities denominated in USD are high and trade openness is (relatively) low. The expansionary appreciation is due to the financial channel: since the value of the banks' liabilities is lowered relative to the assets (due to the appreciation), bank equity and credit increase, which relaxes financial constraints. This raises investment, which in turn increases GDP. These effects are not offset by the decrease in net exports. In contrast, under low debt in USD and high trade openness, the trade channel dominates the financial channel and the appreciation is ultimately contractionary.

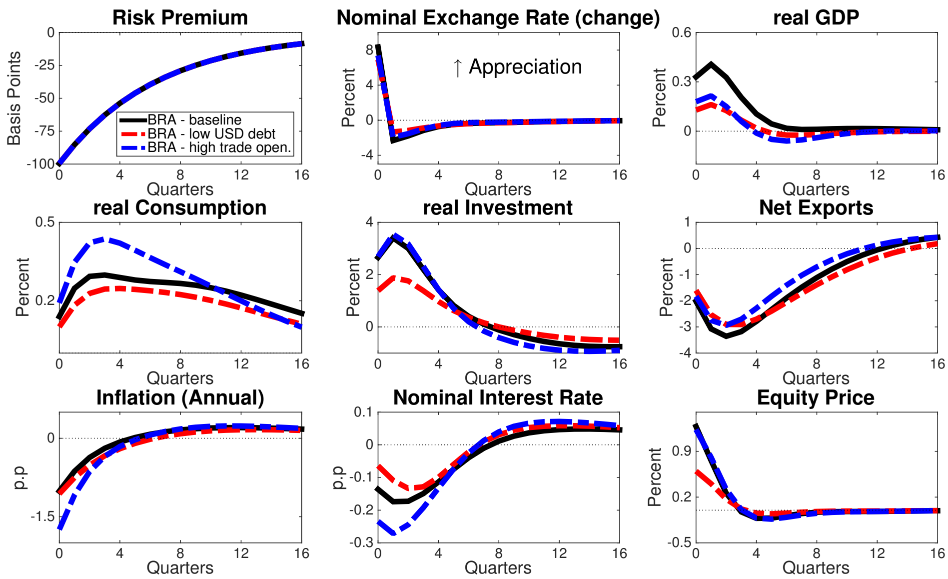
The fact that an appreciation raises real GDP in Brazil and lowers it in Poland is broadly in line with the results from Section 2.4. There, I have shown evidence that if foreign currency exposure is high, an appreciation has expansionary effects on all of GDP's components, except for net exports. If liabilities in USD are low, and thus the financial channel is weak, the appreciation decreases GDP and consumption. I do not find the contractionary effect on consumption in the model. However, it is important to stress that, the estimation in Section 2.4 was done for a panel of 17 different SOEs, not for single countries. It is possible that a LP-IV estimation for single countries could deliver the DSGE model's results.[39]

[39] I chose to estimate the panel LP-IV to exploit the cross-sectional dimension, to counteract the relatively short time series dimension.

A closer look - Trade and financial channels

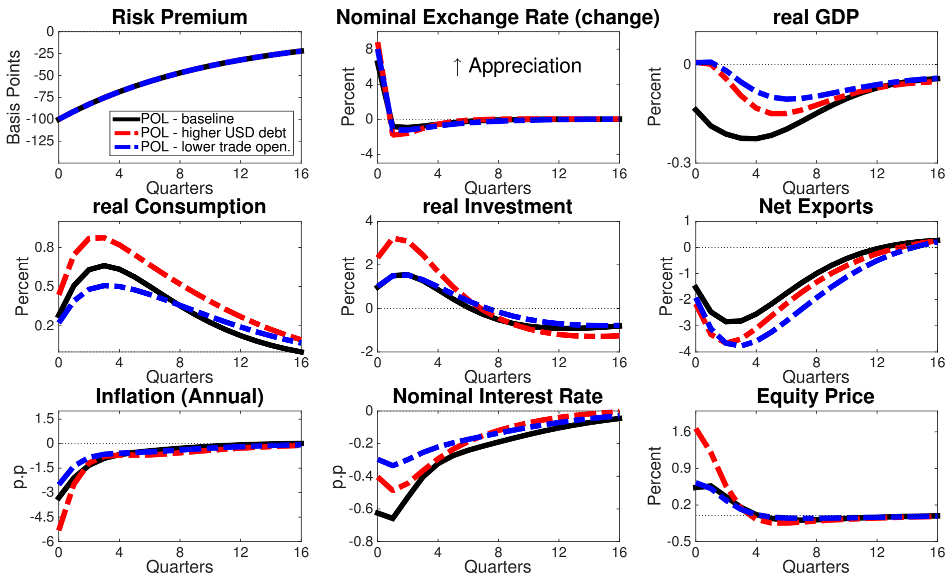
The previous results suggest the financial channel dominates the trade channel if liabilities in USD are high and trade openness is low. The opposite is true when liabilities in USD are low and trade openness high. To further disentangle the channels, I perform the following exercise: I decrease the level of foreign liabilities in Brazil to amount 15% of total bank liabilities, keeping trade openness at its original value. The results are shown in Figure 2.5.3, where the red dotted line depicts this scenario and the black line the baseline results. In this case, the domestic appreciation has weaker effects on consumption, but specially on investment and real GDP. Investment's response to the shock is much weaker (around one percentage point smaller). Equity prices also rise by significantly less than in the baseline.

Figure 2.5.3: Impulse responses from a 100 basis points decrease in the risk premium



Next, I double trade openness (blue line), keeping the fraction of bank's debt denominated in USD at the baseline level. When trade openness is higher, the effect of the UIP shock on the exchange rate is weaker. However, inflation and the policy interest rate decrease by more, due to the stronger decrease in CPI because of the higher share of foreign prices in the consumption basket. Moreover, the responses of equity prices and investment remain roughly unchanged, highlighting the importance of foreign currency exposure in determining the financial effects in this model. Crucially, the resulting appreciation increases consumption by more, since households now consume a higher amount of imported goods, whose price has decreased domestically. Net exports decrease by roughly the same amount, but note that in this scenario, the steady state share of exports and imports over GDP is higher; thus there is a stronger reaction in trade. The stronger reaction of trade indeed weakens the expansionary effects of the financial channel. These results show that foreign currency exposure is an important driver of the financial channel's strength, and in turn, on the overall impact of exchange rate movements in SOEs. At the same time, trade openness has a strong impact on the effects of exchange rate appreciation, which complements the results from section 2.4, adding the trade dimension to the analysis.

Figure 2.5.4: Impulse responses from a 100 basis points decrease in the risk premium



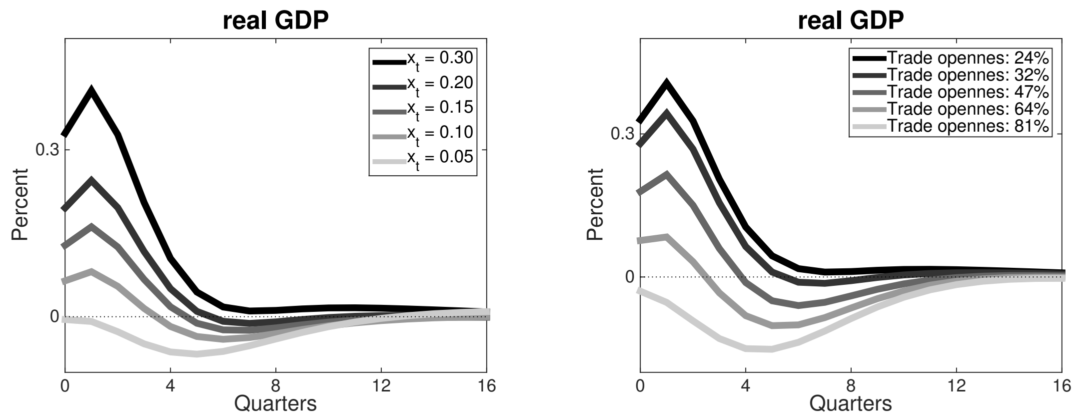
I also perform a similar analysis using the model estimated for Poland. In this case, I increase the level of USD denominated debt to 15% of total banks' liabilities, leaving trade openness at its original level. The results are shown in Figure 2.5.4, where the red lines depict the impulse responses for Poland under a moderately high level of foreign currency exposure, and the black lines the baseline results. The

UIP shock has a larger effect on exchange rates, but also on consumption and more importantly on investment and equity prices. These two variables rise by considerably more, which indicates a stronger effect from the financial channel. Despite these increases, however, the appreciation is still contractionary, as Poland's trade openness is very high and the financial channel does not fully compensate the deterioration of the trade balance. The blue lines show the responses for Poland if trade openness is halved, from around 75% of GDP to around 38%. The amount of liabilities in USD are at the baseline level. Again, the appreciation is still contractionary, though the decrease in GDP is smaller. This works mainly through trade, since the responses of investment and equity prices remain roughly at the baseline level. Again, net exports decrease by more, but this is relative to a smaller steady state level, which means that the contribution of net export to GDP is smaller. This exercise's conclusions are the same as above.

Figure 2.5.5: Brazil: Sensitivity to financial and trade openness

(a) Real GDP response to a 100 basis points decrease in the risk premium

(b) Real GDP response to a 100 basis points decrease in the risk premium



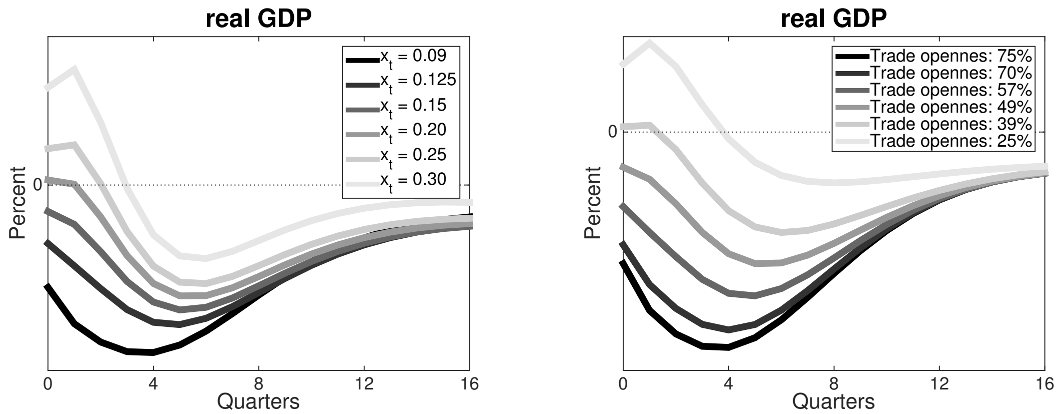
Note: Panel (a) shows the responses of real GDP for different degrees of foreign currency exposure, i.e. for different steady state shares of foreign liabilities x_t. Panel (b) shows the responses of real GDP for different degrees of trade openness, i.e. for different calibrations of home bias in consumption and investment ω.

What the results show is that foreign currency exposure and the financial channel of exchange rate do have a strong impact on how USD exchange rate fluctuations affect economic activity in Brazil and Poland. At the same time, however, the analysis using the open economy New Keynesian model sheds light onto another dimension that was not captured by the empirical analysis using LP-IV: trade openness and the trade channel. To have a closer look at this issue, I computed the response of real GDP to a 100 basis points decrease in the risk premium for Brazil for different degrees of foreign currency exposure (panel a, Figure 2.5.5) and for different degrees of trade openness (panel b, Figure 2.5.5). I did the same with the model estimated with Polish data (Figure 2.5.6).

Figure 2.5.6: Poland: Sensitivity to financial and trade openness

(a) Real GDP response to a 100 basis points decrease in the risk premium

(b) Real GDP response to a 100 basis points decrease in the risk premium



Note: Panel (a) shows the responses of real GDP for different degrees of foreign currency exposure, i.e. for different steady state shares of foreign liabilities x_t. Panel (b) shows the responses of real GDP for different degrees of trade openness, i.e. for different calibrations of home bias in consumption and investment ω.

From this exercise, it is clear that the trade and financial channels work in opposite directions. Further, the strength of the financial channel seems to depend on the amount of debt in USD: the higher the degree of exposure to USD debt, the stronger the expansionary effects of exchange rate appreciations. Moreover, this simulations also complement the insights from form Section 2.4. The trade channel also plays a pivotal role in determining the effects of the exchange rate appreciation: the more open is an economy to trade, the stronger the contractionary effects. Thus, the model suggest that the interaction between the financial and trade channels determine the effects of an appreciation.

However, there are two important caveats. First, with my model I abstract from assets in foreign currency. However, as Dalgic (2018) shows, households in EMEs

– which make up the bulk of the countries I analyze – hold significant amounts of deposits in USD as an insurance mechanism. This, in turn, weakens the expansionary effects of exchange rate appreciations, as households become poorer and their consumption decreases.[40] Moreover, the importance of the trade channel may be overstated in this model, particularly for Poland. This is so, because I use U.S. data to estimate the foreign block of the model, since I am interested in USD exchange rate shocks. However, the U.S. is a minor trading partner for Poland. Only around 3% of Poland's exports and imports are to and from the U.S., and even though Poland USD trade invoicing is higher (around 30% of exports and imports, Gopinath, 2015), the trade channel implied by Poland's 75% trade openness seems too strong.[41]

2.5.3 Implications of the financial channel

The above analysis has shown that UIP shocks, i.e. the main driver of exchange rate, have expansionary effects in this model. Having understood the channels through which the UIP shock works, it is possible to gauge to what extent exchange rate movements – through the financial channel – can dampen of amplify other shocks, such as domestic and foreign monetary policy shocks. This way, I can answer the third research question, namely *(iii) What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE?*

2.5.3.1 Impulse response analysis - U.S. monetary policy shocks

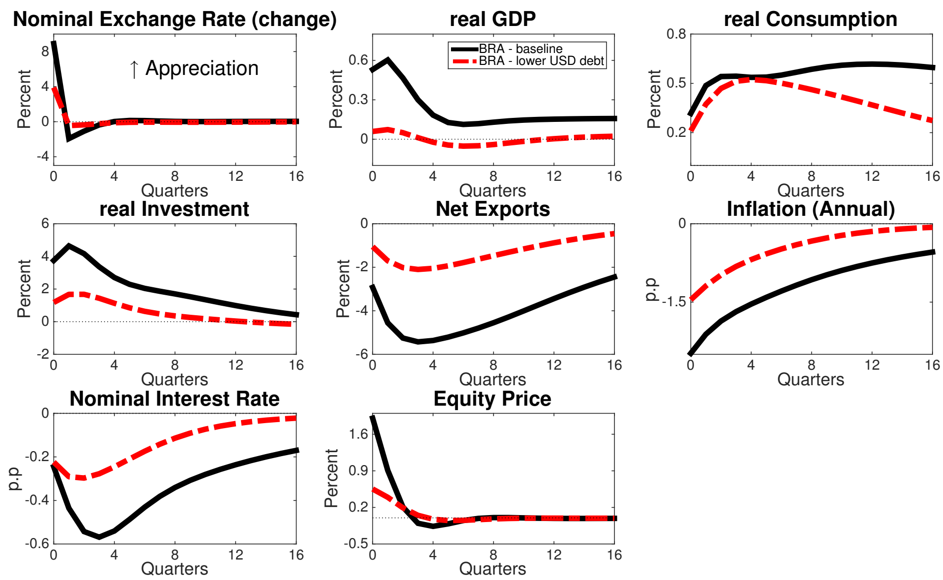
The traditional view on the effects of the exchange rate, i.e. the implications drawn from the Mundell-Fleming model, states that a foreign expansionary monetary policy shock leads to an exchange rate appreciation in the domestic economy, which ultimately leads to lower GDP. The appreciation, in turn, causes inflation to fall. Responding to this, the domestic central bank lowers the policy interest rate, mimicking the foreign monetary policy. However, the financial channel implies that the appreciation of the exchange rate would relax financial constraints which ultimately

[40] However, Dalgic (2018) also finds expansionary effects from an appreciation through the financial channel.

[41] This would be also true for Hungary, which has similar trade intensity with the U.S. and a similar degree of USD invoicing in trade.

boosts economic activity. Thus, through the financial channel, the appreciation could lead to an even stronger comovement of financial conditions in the domestic and foreign economy. In this case, international spillovers may be stronger.

Figure 2.5.7: Impulse responses from a foreign one percent expansionary monetary policy shock

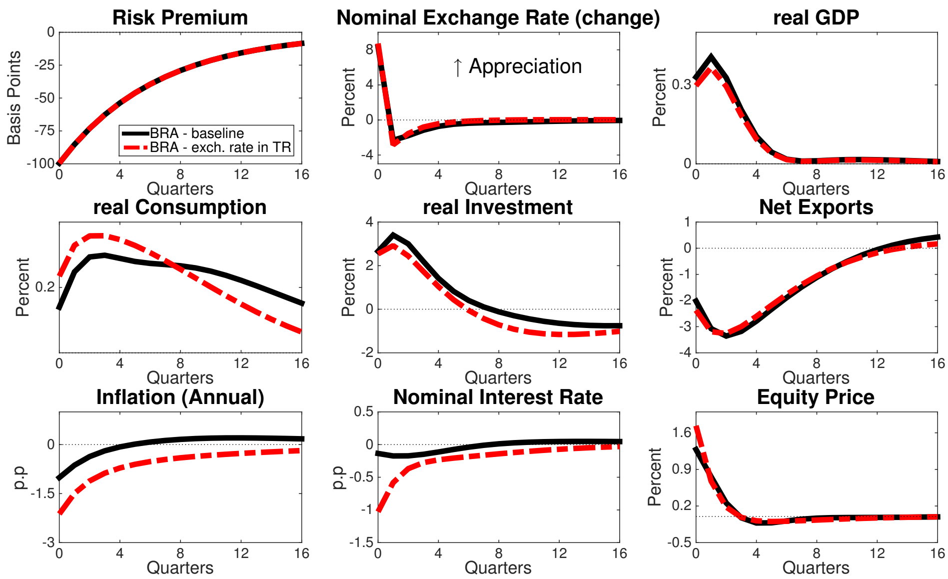


I consider the effects of an expansionary U.S. monetary policy shock on Brazil, for the baseline case and for lower USD debt ($x = 0.15$). Figure 2.5.7 shows the responses to such a shock. The foreign monetary surprise leads to an appreciation of the domestic economy's nominal exchange rate. The appreciation is much stronger in the case of higher USD liabilities, which also leads to a strong decrease in inflation. The response of the central bank is also stronger in the baseline case, as are the increases in real GDP, real investment, real consumption and equity prices. Overall, as in the previous analysis, the effects of an foreign expansionary monetary policy shock are larger, the higher foreign currency exposure is. Thus, these results indicate that foreign monetary policy is amplified by the financial channel of exchange rates. This is in line with the empirical literature. Iacoviello and Navarro (2019) show that high financial vulnerabilities amplify the spill-over effect of U.S. monetary policy in EMEs.

2.5.3.2 Alternative policy response - Exchange rate in the Taylor Rule

It is widely known that central banks of some SOEs, specially EMEs, do not just follow an inflation target but also try to stabilize the exchange rate with their policy actions. As Agustín Carstens, General Manager of the BIS, said in a speech at the London School of Economics: "Irrespective of the official labeling, emerging market economies' central banks have, in practice, attached a significant weight to the exchange rate in the conduct of their monetary policy [...]"[42]. Since most of the countries in my sample are in fact EMEs, it is necessary to study to what extent having the nominal exchange rate in the Taylor affects the responses to an appreciation and also to a foreign monetary policy expansion. For that purpose I add the nominal exchange rate to the Taylor Rule (see Equation 2.22) and study the implications of such a modified Taylor Rule. For ease of exposition, I focus on the model estimated with Brazilian data, where the central bank does not respond to exchange rate changes (black line), and compare the responses to the same model allowing the central bank to respond to the exchange rate with a Taylor Rule coefficient $\omega_e = 0.10$ (red line).

Figure 2.5.8: Impulse responses from a 100 basis points decrease in the risk premium



[42]The speech is available at: https://www.bis.org/speeches/sp190502.htm

Figure 2.5.8 shows the impulse responses after a shock to the UIP condition that decreases the risk premium by 100 basis points. When the central bank tries to stabilize the exchange rate in addition to inflation and GDP, the nominal exchange rate increases by roughly the same percentage points, while inflation decreases by more. Also, the interest rate decrease is much stronger. This translates into a faster decline of the real interest rate and a stronger increase in consumption. However, in general, responses under this new policy regime do not differ much from the baseline scenario. GDP increases on impact by a bit less, but after four quarters the differences in the responses appear to fade out, and investment's responses are almost identical under both policy regimes. A possible explanation for the very similar results is that, while a stronger decrease in the interest rate helps to some extent to mitigate the appreciation, it reinforces other financial effects. Overall, it does not seem that targeting changes in the exchange rate would help stabilize the economy. Moreover, as pointed out by Akinci and Queralto (2018), who use a similar model, there are considerable welfare losses associated with targeting the exchange rate in addition to inflation. However, a welfare analysis is needed to seriously examine this policy regime, which is beyond the scope of this work.

2.6 Conclusion

In this paper, I investigated the macroeconomic and financial effects of USD exchange rate fluctuations in a sample of 17 SOEs. In particular, I examined how the financial channel affects the overall impact of exchange rate fluctuations and assessed to what extent foreign currency exposure determines the relative strength of the financial channel. To address the underlying endogeneity of the exchange rate, I constructed an external instrument based on the UIP condition for the USD exchange rate against major currencies. The empirical results indicated that a domestic appreciation against the USD can potentially have expansionary effects. This can be rationalized by the importance of the financial channel. Further, I found that the strength of the financial channel is determined by the level of foreign currency exposure, since the expansionary effect of a domestic appreciation is larger, the higher foreign liabilities in USD are.

I also estimated an open economy New Keynesian model, in which a fraction of the domestic banks' liabilities is denominated in USD. In line with the empirical results, I found that the level of foreign currency exposure is an important determinant of the strength of the financial channel. Further, the model estimates for Brazil and Poland indicated that, under foreign currency exposure, a domestic appreciation against the USD is expansionary, but higher openness to international trade can weaken these results. By contrast, under low foreign currency exposure and high trade openness, an appreciation is contractionary, but higher debt in USD can flip the results. Thus, the model based analysis indicated that it is the interaction between the financial and trade channels that determines whether an exchange rate appreciation against the USD is expansionary in SOEs. Finally, I also found that the financial channel amplifies the effects of foreign monetary policy in SOEs. My paper implies that taking the financial channel of exchange rates explicitly into account is of utmost importance to fully understand the macroeconomic and financial effects of exchange rate movements and of foreign shocks, and to design and implement policies aimed at mitigating their effects.

Appendix

2.A Data and sources

Countries and sample

Brazil (1996Q1 - 2019Q3), Chile (1996Q1 - 2019Q3), Colombia (2000Q1 - 2019Q3), Czech Republic (1996Q1 - 2019Q3), Hungary (1996Q1 - 2019Q3), India (1996Q2 - 2019Q3), Indonesia (2000Q1 - 2019Q3), Israel (1996Q1 - 2019Q4), Korea (1996Q1 - 2019Q3), Mexico (1996Q1 - 2019Q3), Peru (1996Q1 - 2019Q3), Philippines (1998Q1 - 2019Q3), Poland (1995Q1 - 2019Q3), Russia (2000Q1 - 2019Q3), South Africa (1996Q1 - 2019Q3), Thailand (1996Q1 - 2019Q4), and Turkey (1998Q1 - 2019Q3)

Sources

Table 2.A.1: Data and sources

Variable	Construction and source
real GDP	real GDP in domestic currency Source: Datastream
Investment	real gross fixed capital formation in domestic currency Source: Datastream
Consumption	real domestic private consumption in domestic currency Source: Datastream
Trade balance	Trade balance as % of domestic GDP Source: Datastream
Equity price (SOEs)	MSCI equity prices in domestic currency (for the SOEs) Source: Datastream
Equity price (AEs)	S&P 500, Euro Stoxx, S&P/TSX 60, Nikkei, FTSE 100, SMI, OMXS30, S&P/ASX 200 Source: Datastream
Policy rate (SOEs)	Policy interest rate Source: International Financial Statistics, IMF

Policy rate (AEs)	Shadow rates for the U.S., the Euroarea, the U.K. and Japan Source: Wu and Xia (2016); Xia and Wu (2018), Leo Krippner's estimates for Japan: `https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures`
Lending rate	Lending interest rate Source: International Financial Statistics, IMF
CPI	Consumer price index Source: Datastream
GDP Deflator	GDP deflator Source: Datastream
Credit to the private sector	Credit to the private sector as a percent of GDP Source: Datastream, BIS
VIX	Option-implied volatility index Source: Chicago Board Options Exchange, retrieved from St. Louis FRED
Cross-border banking liabilities	Bank for International Settlements (BIS) reporting claims on each of the SOEs Source: BIS
USD exchange rate	Bilateral USD nominal exchange rate Source: Datastream
USD exchange rate against major currencies	USD nominal effective exchange rate against major economies Source: St. Louis FRED
Foreign currency exposure	Liabilities in USD Source: Bénétrix et al. (2015)
Assets in USD	Assets in USD Source: Bénétrix et al. (2015)

Vulnerability	Vulnerability index Source: Iacoviello and Navarro (2019)
Trade with U.S.	Trade intensity with the U.S. Source: Iacoviello and Navarro (2019)
Trade openness	(exports + imports)/nominal GDP Source: World Bank and Datastream

2.B Panel - Instrumental Variable SVAR

In this section, I discuss the alternative empirical model, namely a panel instrumental variable SVAR similar to Winne and Peersman (2018), as well as the data used in this exercise, and the empirical results.

Using the instrument in an SVAR model

For each SOE, I estimate the following reduced-form VAR model:

$$y_t = c + \Pi(L)y_{t-p} + \Phi(L)x_{t-p} + u_t, \tag{2.B.1}$$

where in the vector of endogenous variables (y_t) contains the bilateral USD exchange rate, the log of industrial production, log of CPI, the policy interest rate, net exports, bilateral capital flows with the US, and CDS. The choice of variables aims at capturing the overall impact of exchange rate movements on the macroeconomy working through the trade and the financial channel, respectively. The vector x_{t-p} contains the exogenous variables, i.e. the (shadow) Federal Funds Rate and the VIX. The 7×1 vector c includes constant terms, the matrix $\Pi(L)$ in lag polynomials captures the autoregressive part of the model, and the vector u_t contains k serially uncorrelated innovations, or reduced-form shocks, with $V(u_t) = \Sigma_u$. Lag length selection for each EME is based on the AIC selection criteria.

Following Hachula and Nautz (2018), I use the proxy SVAR approach developed by Stock and Watson (2012) and Mertens and Ravn (2013) to identify exchange rate shocks with the instrument I constructed in the main part of the paper. Suppose that the reduced-form innovations u_t of the VAR are related to several uncorrelated structural shocks. One of them is the exchange rate shock, ε_t^{fx}, while the others shocks are in the ε_t^*. The relation between the reduced-form and the structural shocks is as follows:

$$u_t = b^{fx}\varepsilon_t^{fx} + b^*\varepsilon_t^*. \tag{2.B.2}$$

The vector b^{fx} captures the impact impulse to an exchange rate shock of size one. The other shocks ε_t^* are uncorrelated with ε_t^{fx} and are left unidentified as they play no role for the question that I aim to answer in the study.

Identification of shocks in the proxy VAR exploits their correlation with a set of proxy variables (or external instruments) η_t, whereas the proxy needs to be uncorrelated with the other structural shocks. Similar to the case in the LP-IV estimation, I need an instrument such that:

$$E(\eta_t \varepsilon_t^{fx}) = \phi \neq 0, \tag{2.B.3a}$$

$$E(\eta_t \varepsilon_t^{*}) = 0. \tag{2.B.3b}$$

The instrument η_t is $\hat{\eta_t}$. As explained in the main text, I have constructed the instrument such that it is unrelated to other shocks that drive SOEs' fundamentals and global variables. Under these conditions, the *relative* responses of two variables i and j in the system to a exchange rate shock, b_i^{fx}/b_j^{fx}, can be consistently estimated using the correlation between η_t and the estimated reduced-form residuals. Note that this *relative* response allows to compute the response of all other variables to a shock that affects the bilateral exchange rate against the USD by a pre-scaled size on impact, say a 1% appreciation. Additionally assuming that $\Sigma_\varepsilon = I$, Mertens and Ravn (2013) show how to then fully retrieve b^{fx}.

With the proxy η_t at hand, there are different options for implement the identification of the VAR model. In this paper, I follow Gertler and Karadi (2015) or Cesa-Bianchi et al. (2015) and employ a two stage least square approach. This method starts with the estimated reduced-form residuals of the VAR, u_t. Then, in the first stage, u_t^{fx}, the reduced-form residual in the equation with the USD exchange rate, is regressed on the instrument η_t:

$$u_t^{fx} = \beta \eta_t + \eta_t^1, \tag{2.B.4}$$

to form the fitted value $\hat{u_t}^{fx}$. Intuitively, in this first stage regression the variation in the reduced-form shock of the exchange rate is isolated that is due to exchange rate shock. The second stage regressions are then carried out as follows:

$$u_t^i = \gamma^i \hat{u_t}^{fx} + \eta_t^2 \tag{2.B.5}$$

where ${\hat{u}_t}^{fx}$ is orthogonal to the error term $\eta_{2,t}$ given assumption (2.B.3b) and u_t^i is the reduced-form residual for each i equation of the VAR. This is done for all equations other than the exchange rate equation. The estimated coefficient $\hat{\gamma^i}$ is a consistent estimate of b_i^{fx}/b_{fx}^{fx}. Along with the assumption that $\Sigma_\epsilon = I$, this then allows to generate impulse response functions to the exchange rate shock.

Usually, it is tested whether there is a sufficiently strong correlation between the instrument and the reduced-form VAR innovations. This is a necessary condition for the instrument to be considered a useful tool for analyzing the underlying drivers of the variables. In particular, if a weak instrument problem is present, the results from the second stage regression will not be informative. I test the relevance of the instrument by adding a constant to equation 2.B.4 and by performing an F-test. The resulting F-statistic in the first stage for the instrument that I obtain is between 10.46 and 62.44, depending on each individual country. This is above the recommended value of ten (see Stock et al., 2002) and indicates that a weak instrument problem is not present.

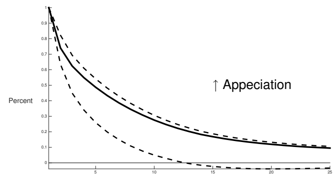
Data

The data set consists of monthly series from 2000 - 2016. The monthly data for the construction of the instruments for the exchange rate movements is obtained from several sources. The USD effective exchange rate against major economies and the VIX were retrieved from the St. Louis Federal Reserve Economic Data, FRED. Further, time series for the industrial production, consumer price index, policy interest rate of the U.S. and the other eight other major economies, were obtained from Datastream. I also use equity price indices and a commodity price index, both retrieved from Datastream.

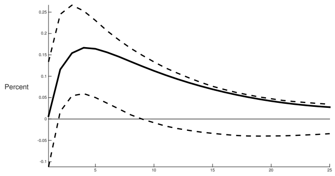
Moreover, the monthly data for the SVAR analysis were retrieved from Datastream and Bloomberg. One exception is the capital flows. The source of bond and equity flows are the monthly estimates of changes in U.S. holdings of foreign securities provided by the Federal Reserve Board. This dataset is based on estimations based on data reported by the Treasury International Capital Reporting System (TIC). For details, see Bertaut and Tryon (2007) and Bertaut and Judson (2014).

Results Panel SVAR

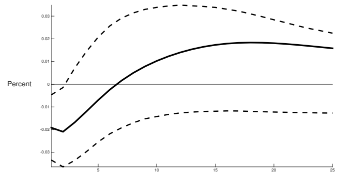
Figure 2.B.1: EMEs' responses to a one percent depreciation of the USD



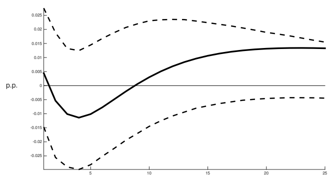
(a) Exchange rate



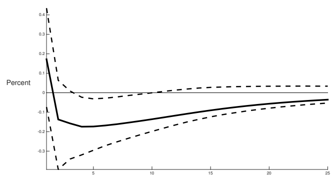
(b) industrial production



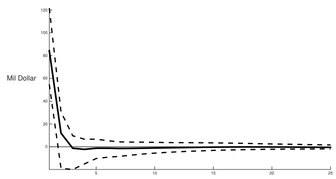
(c) consumer price index



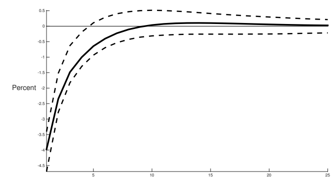
(d) interest rate



(e) net exports



(f) portfolio inflows



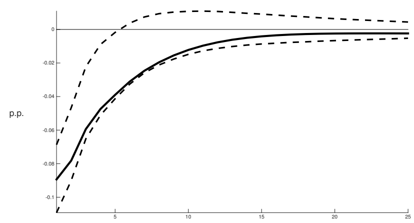
(g) credit default swap

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the EMEs' variables to a one percent depreciation of the USD. Confidence bands are based on 1000 bootstrap replications.

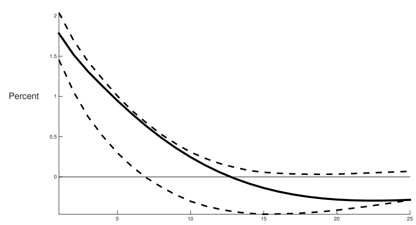
Similar to Winne and Peersman (2018), I calculate the mean response (and confidence bands) fot the 17 SOEs in my sample. Figure 2.B.1 shows the panel results, i.e. the mean impulse responses across countries to a one percent depreciation of the USD . In general, this results strongly hint to the importance of the financial channel, especially the risk-taking channel of Hofmann et al. (2017). The depreciation of the USD, i.e. the appreciation of each SOEs' domestic currency, goes hand-in-hand with increased portfolio inflows (they increase by around 70 million USD on impact), and a decrease of around 3.5 percent in the CDS, the measures for financial conditions and risk respectively. Net exports increase insignificantly on impact due to the value effects after the depreciation of the USD, and decrease significantly by around 0.2 percent after 5 months. The fall in net exports, which would have a negative impact on domestic GDP (proxied by industrial production), appears to be compensated by the looser financial conditions and decreased risk, as predicted by Hofmann et al. (2017), since IP increases significantly, reaching a peak of around 0.2 percent after 5 months. Finally, prices measured by the CPI decrease on impact due to lower import prices in EMEs, and increase insignificantly, while interest rates do not have a significant reaction. Summing up, an appreciation against the USD goes hand in hand with reduced risk, which in turn attracts capital inflows, loosening financial conditions and boosting output, even though net exports are significantly reduced.

Furthermore, Figure 2.B.2 shows the impulse responses of alternative measures of risk and financial conditions. The government bond yield spread decreases on average by 0.8 percentage points after the one percent appreciation vis-a-vis the USD, while equity prices increase significantly by around 1.6 percent. This is in line with the results and considerations above.

Figure 2.B.2: EMEs' responses to a one percent depreciation of the USD - alternative measures of risk and financial conditions



(a) 10-year government bond yield spread



(b) equity price index

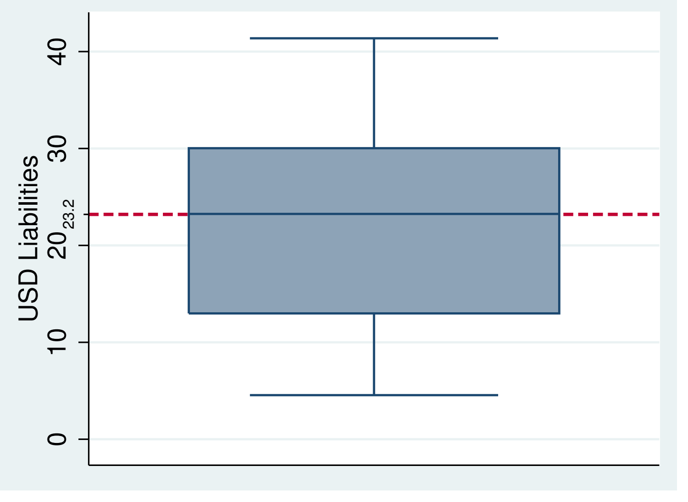
Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the EMEs' variables to a one percent depreciation of the USD. Confidence bands are based on 1000 bootstrap replications.

To sum up, the results from the proxy SVAR indicate that on average a currency appreciation against the USD is expansionary in the set of SOEs. The results also suggest that the currency appreciation is expansionary because financial effects dominate trade effects that would work in the opposite direction. This is in line with the findings in section 2.4.

2.C Appendix for Section 2.4

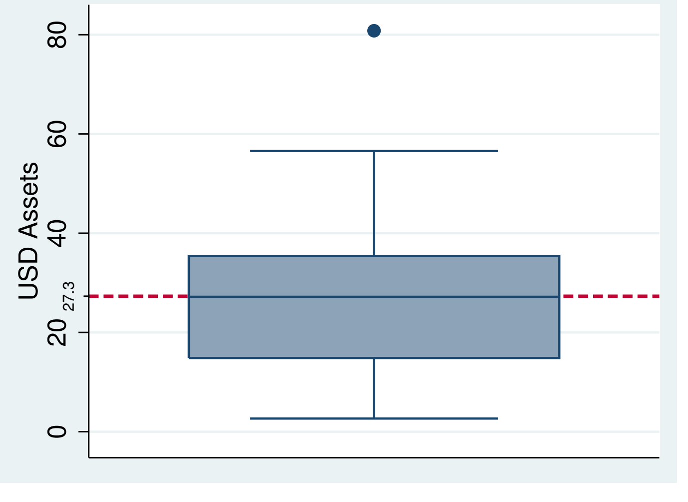
USD Liabilities, assets and trade openness

Figure 2.C.1: Liabilities in USD (sample average per country): Distribution



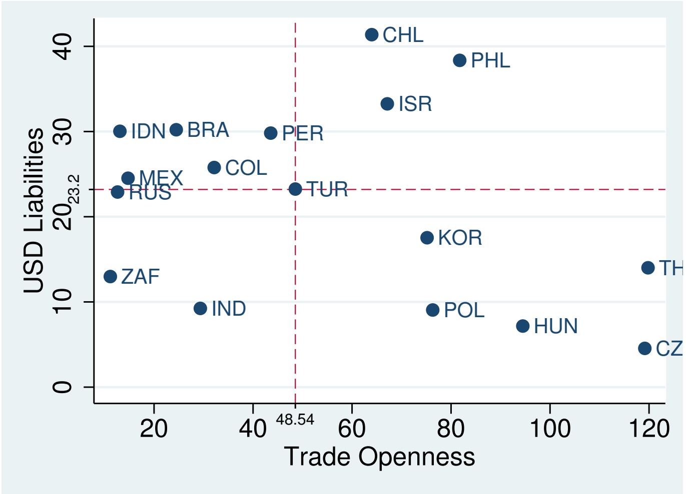
Note: The dashed red line depicts the median.

Figure 2.C.2: Assets in USD (sample average per country): Distribution



Note: The dashed red line depicts the median.

Figure 2.C.3: Liabilities in USD and trade openness



Note: The dashed lines depict the medians.

Exchange rate correlations

Table 2.C.1: Correlations of the USD exchange rate against major currencies and USD exchange rate against individual SOEs' currencies

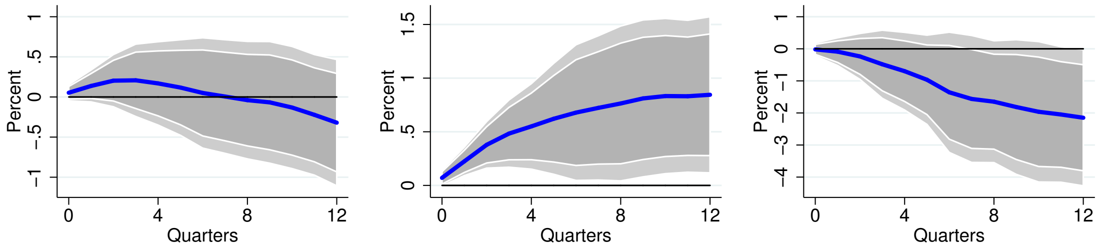
Brazil	Chile	Colombia	Czech Rep.	Hungary	India	Indonesia	Israel	Korea
0.61	0.67	0.78	0.94	0.75	0.21	0.22	0.51	0.47

Mexico	Peru	Philippines	Poland	Russia	S. Africa	Thailand	Turkey	
0.16	0.86	0.64	0.84	0.33	0.33	0.74	0.14	

Robustness checks

Figure 2.C.4: Estimation of the instrument: Only contemporaneous regressors

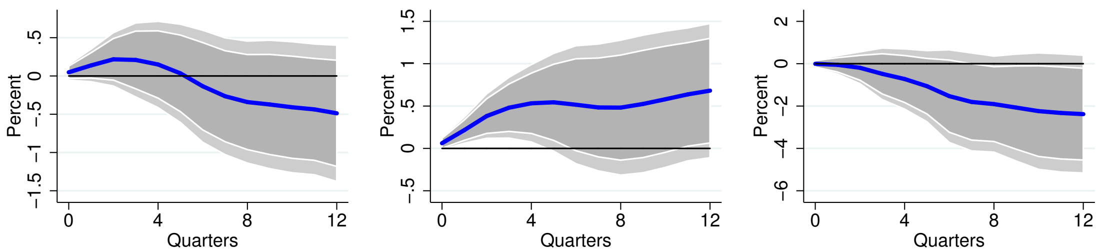
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.C.5: Estimation of the instrument: Equity price indices for all major economies

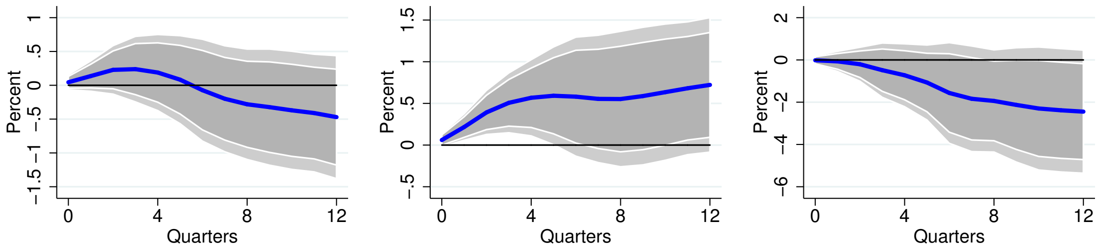
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.C.6: Estimation of the instrument: Dummy for the third and fourth quarter in 2008

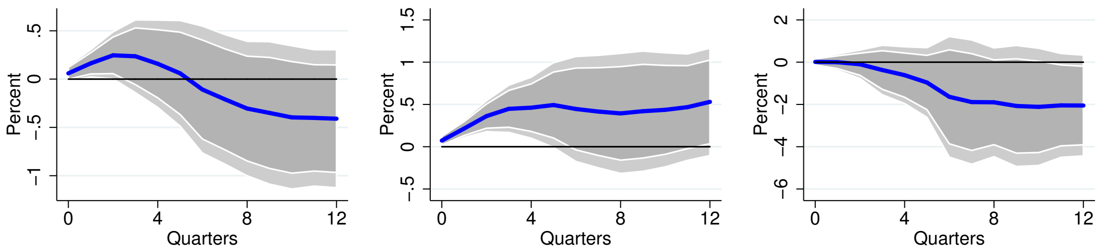
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.C.7: LP-IV estimation: Four lags

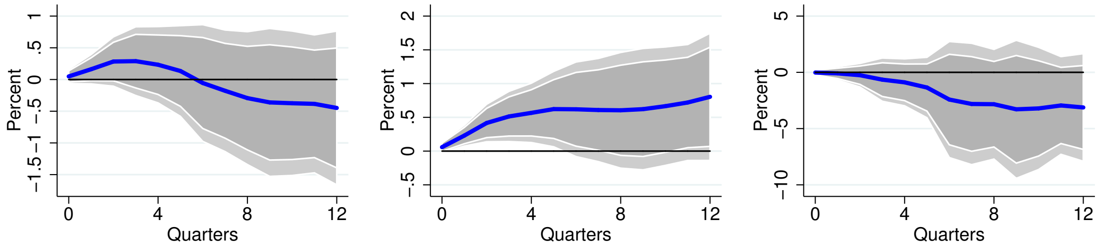
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.C.8: LP-IV estimation: Commodity price index as an exogenous variable

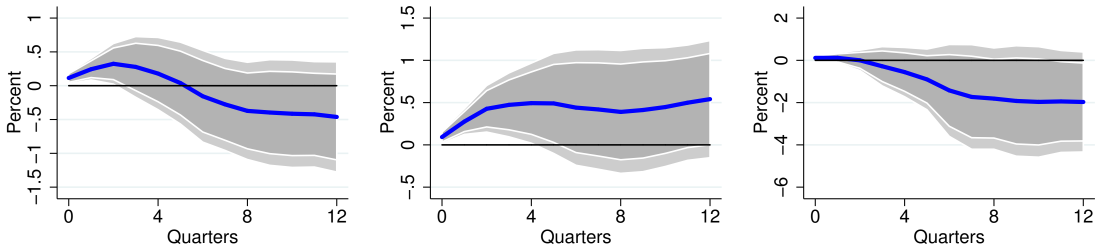
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 2.C.9: LP-IV estimation: U.S. GDP as an exogenous variable

(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

2.D Appendix DSGE model

DSGE model: Equilibrium equations

Firms

$$y_t^H = A_t k_{t-1}^{\alpha} l_t^{1-\alpha} \tag{2.D.1}$$

$$\frac{(1-\alpha)}{\alpha} = \frac{w_t l_t}{\big(q_{t-1} R_t^k - q_t(1-\delta)\big)\, k_{t-1}} \tag{2.D.2}$$

$$R_t^k = \frac{Z_t + (1-\delta) q_t}{q_{t-1}} \tag{2.D.3}$$

$$mc_t = \tilde{\xi}_t^c \frac{1}{A_t} \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha} \left(\frac{Z_t}{\alpha}\right)^{\alpha} \tag{2.D.4}$$

$$p_t^H = \frac{\eta}{\eta-1} mc_t - \frac{\kappa}{\eta-1} \frac{\pi_t^H(\pi_t^H - 1)}{y_t^H} + \frac{\kappa}{\eta-1} \mathrm{E_t} \left(\frac{\pi_{t+1}^H(\pi_{t+1}^H - 1)}{y_t^H}\right) \tag{2.D.5}$$

$$\pi_t^H = \frac{p_t^H}{p_{t-1}^H} \pi_t \tag{2.D.6}$$

$$p_t^F = \frac{\eta}{\eta-1} s_t - \frac{\kappa}{\eta-1} \frac{\pi_t^F(\pi_t^F - 1)}{y_t^F} + \frac{\kappa}{\eta-1} \mathrm{E_t} \left(\frac{\pi_{t+1}^F(\pi_{t+1}^F - 1)}{y_t^F}\right) \tag{2.D.7}$$

$$\pi_t^F = \frac{p_t^F}{p_{t-1}^F} \pi_t \tag{2.D.8}$$

$$ex_t = \left(s_t^{\varphi} y_t^*\right)^{(1-\rho_{ex})} \left(ex_{t-1}\right)^{\rho_{ex}} \qquad \text{Exports} \tag{2.D.9}$$

$$\frac{s_t}{s_{t-1}} = \frac{\Delta e_t \pi_t^*}{\pi_t} \qquad \text{Real exchange rate} \tag{2.D.10}$$

Households

$$c_t = \left[\omega^{\frac{1}{\gamma_c}} \left(c_t^H\right)^{\frac{\gamma_c-1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}} \left(c_t^F\right)^{\frac{\gamma_c-1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c-1}} \tag{2.D.11}$$

$$\frac{c_t^H}{c_t^F} = \left(\frac{p_t^H}{p_t^F}\right)^{-\gamma_c} \frac{\omega}{1-\omega} \tag{2.D.12}$$

$$1 = \left(\omega \left(p_t^H\right)^{1-\gamma_c} + (1-\omega) \left(p_t^F\right)^{1-\gamma_c}\right) \tag{2.D.13}$$

$$\tilde{\xi}_t^g \left(c_t - h c_{t-1}\right)^{-\sigma_c} = \lambda_t^m \tag{2.D.14}$$

$$\tilde{\xi}_t^g \frac{\zeta_0 l_t^{\zeta}}{w_t} = \lambda_t^m \tag{2.D.15}$$

$$R_t \mathrm{E_t} \Lambda_{t,t+1} = 1 \tag{2.D.16}$$

$$\mathrm{E_t} \Lambda_{t,t+1} = \beta \mathrm{E_t} \frac{\lambda_{t+1}^m}{\lambda_t^m} \tag{2.D.17}$$

$$\mathrm{E_t}\Lambda_{t,t+1}\frac{R^k_{t+1}q_t}{q_t+\varkappa k^h_t}=1 \tag{2.D.18}$$

$$R_t=\frac{r^n_t}{\mathrm{E_t}\pi_{t+1}} \qquad \text{Real interest rate} \tag{2.D.19}$$

Capital producers

$$i_t=\left[\omega^{\frac{1}{\gamma_c}}\left(i^H_t\right)^{\frac{\gamma_c-1}{\gamma_c}}+(1-\omega)^{\frac{1}{\gamma_c}}\left(i^F_t\right)^{\frac{\gamma_c-1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c-1}} \tag{2.D.20}$$

$$\frac{i^H_t}{i^F_t}=\left(\frac{p^H_t}{p^F_t}\right)^{-\gamma_c}\frac{\omega}{1-\omega} \tag{2.D.21}$$

$$p^I_t=\left(\omega\left(p^H_t\right)^{1-\gamma_c}+(1-\omega)\left(p^F_t\right)^{1-\gamma_c}\right) \tag{2.D.22}$$

$$p^I_t=q_t\left(1-\frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}}-1\right)^2-\kappa_I\left(\frac{i_t}{i_{t-1}}-1\right)\left(\frac{i_t}{i_{t-1}}\right)\right)+\mathrm{E_t}\left[\Lambda_{t,t+1}q_{t+1}\kappa_I\left(\frac{i_t}{i_{t-1}}-1\right)\left(\frac{i_t}{i_{t-1}}\right)^2\right] \tag{2.D.23}$$

$$k_{t+1}=\tilde{\xi}^i_t\left(1-\Phi\left(\frac{i_t}{i_{t-1}}\right)\right)i_t+(1-\delta)k_t \tag{2.D.24}$$

$$\Phi\left(\frac{I_t}{I_{t-1}}\right)=\frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2$$

Banks

$$\mu_t = \mathrm{E_t}\left[\Omega_{t+1}\left(\frac{Z_{t+1}+(1-\delta)q_{t+1}}{q_t} - R_{t+1}\right)\right] \tag{2.D.25}$$

$$\mu_t^* = \mathrm{E_t}\left[\Omega_{t+1}\left(R_{t+1} - \frac{e_{t+1}}{e_t}R_{t+1}^*\Psi_t\right)\right], \tag{2.D.26}$$

$$\Psi_t = \exp\left(\psi_1 \hat{d}_{t+1}^*\right)\psi_t, \tag{2.D.27}$$

$$\nu_t = \mathrm{E_t}\left[\Omega_{t+1}R_{t+1}\right] \tag{2.D.28}$$

$$\tilde{\mu_t^*} = \frac{\mu_t^*}{\mu_t} \tag{2.D.29}$$

$$\phi_t = \frac{\nu_t}{\Theta(x_t) - (\mu_t + \mu_t^* x_t)} \tag{2.D.30}$$

$$\psi_t = \Theta(x_t)\phi_t \tag{2.D.31}$$

$$x_t = \frac{1}{\tilde{\mu_t^*}}\left(-1 + \sqrt{1 + \frac{2}{\gamma}\tilde{\mu_t^*}^2}\right) \tag{2.D.32}$$

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right) \tag{2.D.33}$$

$$\mathrm{E_t}\Omega_{t+1} = \mathrm{E_t}\Lambda_{t,t+1}\left(1 - \sigma + \sigma\psi_{t+1}\right) \tag{2.D.34}$$

$$x_t = \frac{s_t d_t^*}{q_t k_t^b} \tag{2.D.35}$$

Aggregation

$$n_t = (\sigma + \xi)(Z_t + (1-\delta))k_{t-1}^b - \sigma R_t d_{t-1} - \sigma s_t R_{t-1}^* d_{t-1}^* \tag{2.D.36}$$

$$\chi(k_t^h) = \frac{\varkappa}{2}(k_t^h)^2 \tag{2.D.37}$$

$$qtk_t^b = \phi_t n_t \tag{2.D.38}$$

$$qtk_t^b = n_t + d_t + s_t d_t^* \tag{2.D.39}$$

$$h_t = k_t^b + k_t^h \tag{2.D.40}$$

$$y_t^H = c_t^H + i_t^H + g_t^H + ex_t^H + \left(p_t^H\right)^{-\gamma}\frac{\kappa}{2}\left(\pi_t\frac{p_t^H}{p_{t-1}^H} - 1\right)^2 + \chi(k_t^h) \tag{2.D.41}$$

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-\gamma}\frac{\kappa}{2}\left(\pi_t\frac{p_t^F}{p_{t-1}^F} - 1\right)^2 \tag{2.D.42}$$

$$gdp_t = c_t^H + i_t^H + g_t^H + ex_t^H \tag{2.D.43}$$

$$d_t^* = R_{t-1}^* d_{t-1}^* + y_t^F - \frac{1}{s_t} ex_t. \tag{2.D.44}$$

$$r_t^n - r^n = (1-\rho_i)\left[\omega_i(\pi_t - \pi) + \omega_y(gdp_t - gdp) + \omega_e(\Delta e_t)\right] + \rho_i(r_{t-1}^n - r^n) + \xi_t^{MP} \tag{2.D.45}$$

$$g_t^H - g^H = \rho_{gov}\left(g_{t-1}^H - g^H\right) \tag{2.D.46}$$

Foreign economy and shocks

The foreign economy is given by:

$$y_t^* - y^* = \mathrm{E_t}\left(y_{t+1}^* - y^*\right) - \frac{1}{\gamma_{y^*}}\left(R_t^* - R^*\right) + \tilde{\xi}^{y_t^*} \tag{2.D.47}$$

$$\pi_t^* - \pi^* = \beta^* \mathrm{E_t}\left(\pi_{t+1}^* - \pi^*\right) + \frac{1}{\kappa_{\pi^*}}\left(y_t^* - y^*\right) + \tilde{\xi}^{\pi_t^*} \tag{2.D.48}$$

$$R_t^* = \frac{r_t^*}{\mathrm{E_t}\pi_t^*} \tag{2.D.49}$$

$$r_t^* - r^* = (1-\rho_i^*)\left[\omega_i^*(\pi_t^* - \pi^*) + \omega_y^*(y_t^* - y^*)\right] + \rho_i^*(r_{t-1}^* - r^*) + \xi_t^{MP^*} \tag{2.D.50}$$

AR(1) processes for all shocks except for the domestic and foreign monetary policy shocks. The processes take the following form:

$$a_t = a = \rho_a \left(a_{t-1} - a\right) + \epsilon_t,$$

where a_t is the exogenous variable of interest and ϵ_t is the shock of interest.

Data for estimation

Figure 2.D.1: Brazil: Demeaned data for estimation

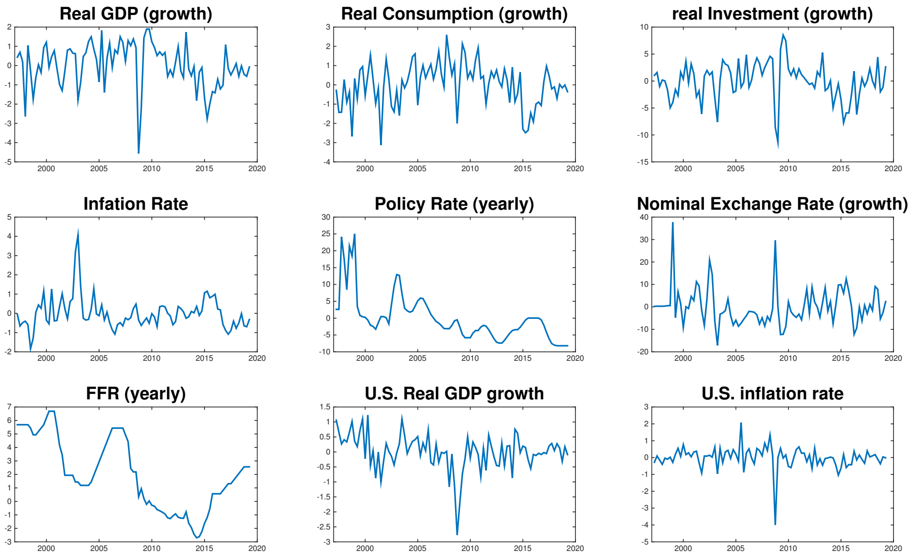
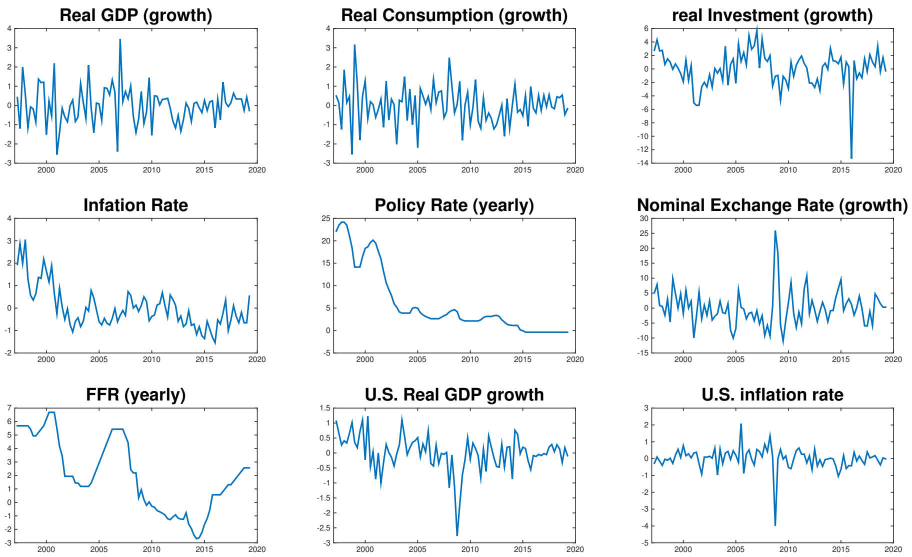


Figure 2.D.2: Poland: Demeaned data for estimation



CHAPTER 3

The Impact of International Capital Flows on Domestic Investment[1]

3.1 Introduction

In the mid 1990s, emerging market economies (EMEs) started an unprecedented process of financial account liberalization, which lead to higher capital flows, and to a heated debate about the effects of these flows on the economy. About a decade later, as several major economies implemented unconventional monetary policies in response to the global financial crisis and the Eurozone crisis, EMEs experienced again large and volatile flows of capital. This revived the discussion about the determinants of those flows[2] and about their short- and medium-term effects on economic and financial conditions.

In this paper, we revisit this discussion and re-assess the relationship between capital flows and investment, a key determinant of medium-term economic development in EMEs. In particular, we study whether changes in capital flows affect domestic investment significantly. Moreover, we compare the effects in EMEs with those in advanced economies (AEs) and assess whether economic responses in EMEs and AEs differ from each other. We also aim to understand what accounts for the differences. We use Local Projections Instrumental-Variable (LP-IV) methods to estimate the impact of capital flows and its subcategories, i.e. foreign direct investment (FDI), portfolio flows and credit, on investment for a panel of EMEs and AEs.

[1]This chapter is based on a research paper that is joint work with Florentine Schwark.
[2]See Fratzscher (2012), Forbes and Warnock (2012), Ahmed and Zlate (2014) for a detailed analysis on the determinants of capital flows.

To address the potential endogeneity of capital flows, we follow Mody and Murshid (2005) and construct an instrument based on the weighted sum of capital flows into and from a region. This instrument is strongly correlated with capital flows into and from an individual country and at the same it is likely that it is exogenous to single countries in our sample (Mody and Murshid, 2005; Mileva, 2008).

Our main results can be summarized as follows. First, in a static setting, we find that net capital inflows increase investment significantly in EMEs, while the effect of capital flows in AEs is much weaker. Moreover, we find that the lending interest rate - our proxy for domestic financial conditions - has a weaker effect on investment in EMEs than in AEs. Our impulse responses estimated with local projections also confirm the static results: the increase in investment due to higher capital flows is stronger and more persistent in EMEs. Regarding the composition of capital inflows, we find that net FDI increases investment significantly, while net portfolio inflows have no significant impact. This result is in line with Mody and Murshid (2005) who argue that FDI has a higher level of productivity than portfolio flows due to profound knowledge of direct investors regarding the domestic economy. We also find that portfolio flows firms have a significant impact, which might be due to the same reasoning. Finally, we examine whether *foreign* capital flows (gross inflows) have a different impact on the economy than *domestic* ones (gross outflows)[3]. In this case, we find that capital inflows have generally a larger effect on investment than outflows, which shows that foreign capital is more productive than domestic one, maybe because foreign flows are accompanied by foreign know-how or human capital.

Next, we aim to understand which country characteristics account for the significant differences between the responses in EMEs and AEs. There are several possible explanations for our results, but with our empirical model we can test two of them. First, as pointed out by Mody and Murshid (2005), capital inflows may be more productive in countries where capital is relatively scarce. This implies that capital flows have a larger impact on investment in countries that are relatively poor. If this is true, then the impact of capital flows in relatively rich EMEs would be weaker than in relatively poor EMEs. Thus, to test whether a country's wealth determines the

[3]See Forbes and Warnock (2012) for the a discussion on gross inflows and outflows and the importance of studying them separately.

effect of capital flows on investment and thus accounts for the distinct response in AEs, we condition the responses in EMEs to the level of GDP per capita. Moreover, a second explanation would be financial development. EMEs have less developed financial systems than AEs, so they may be more dependent on foreign capital to finance investment, hence the larger impact of capital flows on EMEs' investment. To test this, we condition the response of investment in EMEs on the degree of financial development. EMEs with relatively more developed financial systems would profit less from capital flows than EMEs with more developed financial system. We find robust evidence supporting the latter hypothesis and show that financial development is the key determinant of the strength of the effect of capital flows on investment.

One implication of our findings is that capital flows in general, and FDI in particular, have indeed a large, positive impact on EMEs's investment and therefore also possibly on the future production capacity. Thus, EMEs would profit from creating an environment that is attractive to foreign capital. Moreover, since we observe that capital flows have stronger effects in countries with less developed financial sectors, we can infer that those countries are less resilient to adverse effects of large swings in capital flows. Thus, a further implication of our findings is that financial development is important to strengthen a country's resilience to phenomena like sudden stops or capital surges.

Our paper relates to several strands of literature. First, it is close to studies on the impact of net capital flows on investment in EMEs for earlier periods. Bosworth and Collins (1999) concluded that capital inflows into EMEs have significantly raised domestic investment. They found that this effect is even stronger for FDI flows. Similarly, Mody and Murshid (2005) find a positive effect when assessing the impact of flows on investment. In a very similar vein, Mileva (2008) analyzes the effect of FDI, foreign loans, and portfolio flows on domestic investment in a panel of Eastern European countries and former Soviet republics. She also finds a significant effect, especially for FDI flows. The first two papers use data from 1970s to the late 1990s, while the latter focuses on the period 1995-2005. Moreover, Fukuda et al. (2013) study the effect of U.S. monetary policy prior to the financial crisis on some advanced economies as well as on Latin American and Asian countries. They find a stronger spillover effects on output during the 1990s than during the 2000s. Further, they build a DSGE model to provide a theoretical framework to their empirical findings. Furthermore, Igan et al. (2016) study whether capital inflows have an impact on industry growth in EMEs, and whether these effects are potentially influenced by the composition of capital inflows, the dependency of different sectors on foreign finance. They find a significant impact of inflows on growth in industries that are particularly dependent on external finance. Finally, Desai et al. (2005) investigate whether FDI outflows decrease the level of domestic investment in the U.S., which relates to our analysis of the effects of net capital flows on advanced economies.

Second, this study is related to the large literature on the benefits and costs of financial account liberalization including global financial integration and relaxation of capital account restrictions, especially for EMEs and developing countries. On the one side, some studies suggests that financial account openness is a source of instability and propose the introduction of capital controls and other macro-prudential measures (e.g., Rodrik, 1998, Bhagwati, 1998 and Ostry et al., 2010). On the other side, other present evidence that financial integration has positive effects on growth (Bekaert et al., 2005, Kose et al., 2011), depending on the degree of financial depth and institutional quality. Also Kose et al. (2006) find that financial globalization can be beneficial for developing countries after an extensive literature review. The results in our paper suggest that while an increase in capital flows increases investment, EMEs' dependency on foreign capital due to less developed financial systems may pose a risk, as swings in capital flows may affect EMEs strongly.

Finally, our essay is linked to studies on the connection between financial development, investment and economic growth. Levine (2005) presents model-based and empirical evidence that imply that better developed financial systems enhances investment and growth, as financial systems ease financing constrains that firms may face. Finally, Xu (2000) shows evidence that investment is an important channel, through which financial development affects growth.

The remainder of the article is structured as follows: Section 3.2 comprises the description of the data, and our empirical model. In Sections 3.3 and 3.4 we present our results, and Section 3.5 concludes.

3.2 Data and empirical model

3.2.1 Data

Our data set consists of annual data covering 34 EMEs and 26 AEs from 1999 - 2019. We have an unbalanced panel, thus for some countries we have slightly shorter time series. We use time series on real investment, capital flows and its components, real GDP, lending and policy interest rates, credit to the private sector as a percentage of GDP, the primary balance and the VIX. All variables, except for the interest rates and those that are expressed as percentage of GDP, are transformed by taking their logarithm. Further, we use the IMF's financial development index, the financial account openness index by Chinn and Ito (2006) and the vulnerability index by Iacoviello and Navarro (2019). Tables 3.A and 3.A.2 in the appendix show the full list of countries, of the data, the transformations and the sources.

3.2.2 Empirical model

Similar to Mody and Murshid (2005) and Mileva (2008), we are interested in the effects of the capital flows and its components, net and gross, on domestic investment. For that purpose, we estimate the cumulative response of investment, $I_{i,t+h} - I_{i,t-1}$, at horizon h, to an exogenous change in capital flows. Following Jordà et al. (2015), these effects are modeled as:

$$I_{i,t+h} - I_{i,t-1} = \alpha_i + \beta_h K_{i,t} + \Pi_h(L)\Delta I_{i,t-1} + \Xi_h(L)\Delta x_{i,t-1} + u_{i,t+h},, \qquad (3.1)$$

where i and t country and time indices, α_i are country fixed effects, $\Pi_h(L)$ and $\Xi_h(L)$ are polynomials in the lag operator, with $L = 1$ in the baseline. $K_{i,t}$ is a matrix that contains either net, gross, FDI, loans, or portfolio flows (all as a share of GDP). The matrix $x_{i,t-1}$ is a set of controls such as real GDP, the lending interest rate, credit to the private sector as a percent of GDP, the primary balance as a percent of GDP and the VIX. The latter is our measure for country-invariant uncertainty and for the global financial cycle (see Miranda-Agrippino and Rey, 2015). We also include the lagged value of investment. Note that all variables enter the equation in first differences. We consider $h = 0, 1, 2, 3, 4$, measuring the effects up to four years ahead. Accordingly, β_h measures the dynamic average cumulative response of investment at horizon h to a change in capital flows $K_{i,t}$. Following Ben Zeev (2019), we use Driscoll and Kraay (1998) standard errors that allow arbitrary correlations of the error term across countries and time.

Finally, for the estimation of Equation (3.1), we use aggregated net and gross capital flows data as well as disaggregated data by type of flows. We do this for several reasons: First, we use data on net inflows to obtain a general understanding of the effects of in- or decreasing financial flows. Second, we disaggregate the data to analyze the absolute and relative importance of different types of flows, e.g. whether the effect on investment of FDI is larger than that of loans or whether portfolio flows are more productive than loans. Finally, we want to differentiate between gross and net capital outflows because, as Mileva (2008) argues, foreign capital (gross capital inflows) may be more productive than domestic capital (gross capital outflow). More importantly, Broner et al. (2013) and Forbes and Warnock (2012) have shown that, especially for the period in which we are interested, gross flows have been more volatile and large, while net flows have been relatively more stable. Therefore, only studying net inflows may mask interesting dynamics. Also, extreme episodes of gross capital inflows and outflows have different effects on the economy (Forbes and Warnock, 2012), thus it can be argued that in general different types of gross capital inflows and outflows can affect the economies differently.

3.3 Panel Results

3.3.1 Instrument and first stage regressions

As discussed in the introduction and highlighted by Mody and Murshid (2005), we encounter an important issue while estimating Equation (3.1), namely the problem of reverse causality. It may run from investment to capital flows, not the other way around as implied by Equation (3.1). Thus an OLS estimation would lead to inconsistent estimates. To deal with this problem, we follow Mody and Murshid (2005) and Mileva (2008), and we build an instrument based on the GDP weighted sum of capital flows to different regions. For example, in the case of Brazil, our instrument is the weighted sum of capital flows into and from the Latin American countries in our sample minus the flows into and from Brazil.[4] We are aware that these regional flows only reflect supply side or push factors, so this variable would obviously not account for pull factors attracting capital flows to individual countries. However, as discussed below, regional flows prove to be a good instrument for capital flows.[5] With the instrument at hand, we estimate Equation (3.1) with Two Stage Least Squares, following Jordà et al. (2015).

Table 3.3.1: First stage regressions

Independent Variables	Capital flows or its components (as % of GDP)			
	(1)	(2)	(3)	(4)
	EMEs baseline	AEs baseline	EMEs inflows	EMEs outflows
Regional net inflows§	0.11*** (33.22)	0.04*** (13.01)		
Regional inflows§			0.11***(34)	
Regional outflows§				0.11*** (37.21)
Lag investment	0.07 **	0.59	0.003	-0.07**
Real GDP	-0.1	-1.39	0.074	0.16
Lending rate	-0.011	0.40	0.016	0.02
Primary balance (% of GDP)	-0.03	0.58	-0.04	-0.01
Terms of trade	-0.017	0.31	-0.007	0.008
VIX	-0.0008	0.005	-0.0007	-0.0005
R^2	0.29	0.09	0.35	0.18
Number of observations	587	452	587	
Number of countries	34	26	34	34

§ as % of GDP

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The F-statistics of the instruments are in parenthesis.

In order for our instrument to be valid, regional flows should be correlated with capital flows into individual EMEs and AEs. Table 3.3.1 reports the results of the first stage regression for four specifications. The first two columns shows the results from the baseline specification for EMEs and AEs respectively. The third and fourth column reports the results when we consider inflows and outflows separately and show only the coefficients for EMEs. To see the results when we study the effects

[4] We do not split AEs into regional groups, and we consider them to be all in one region. Thus the instrument would reflect the global pool of capital available in AEs.

[5] A similar approach was proposed by Blanchard et al. (2015).

of the different components of capital flows, see the fifth, sixth and seventh column of Table 3.A.3 in the appendix.[6] The F-statistic of regional flows (in parenthesis), which is always well above 10, suggests that the instrument is relevant, in the sense of Stock and Watson (2018). Moreover, regional flows should be exogenous to single countries in our sample. Since the regional flows variable for an individual country does not include the capital flows into that specific country, the instrument should be unrelated to all other domestic variables in that individual country. In this sense, as suggested by Mody and Murshid (2005) and Mileva (2008), the instrument is likely to be exogenous.

3.3.2 The capital flows - investment relation: EMEs vs. AEs

We begin by comparing how net capital inflows, and gross inflows and outflows affect investment in EMEs and AEs. First, we aim to have a broad picture about the relative importance of capital flows in determining domestic investment, thus we are not only interested in the coefficient β_h, but also on the estimated coefficients of the other controls. Thus, Table 3.3.2 reports the estimates of Equation (3.1) for $h = 0$. The first column shows the baseline estimation for EMEs, the second the baseline estimation for AEs, the third the estimation with gross inflows and outflows for EMEs, and the last one the estimates for the components of net capital inflows. The estimated coefficients for capital flows can be interpreted as the response of investment to an increase in capital flows on impact.

We find that in EMEs, a one percentage point increase in net capital inflows increases investment significantly by 0.91 percent. An increase in GDP raises investment significantly by 0.49 percent, an increase in the lending interest rate decreases investment significantly by 0.34 percent, as expected, and a one percent improvement of the terms of trade increases it significantly by 0.23 percent. We do not find a significant effect of lagged investment, the primary balance or the VIX. Moving to the estimation for AEs (the second column), we find that net capital inflows have a much weaker impact in AEs, but at the same time the lending rate and the primary balance have a much stronger effect, decreasing investment by 2.57 percent and increasing it by 0.69 percent respectively. Summing up, we find that capital flows have stronger effects on investment in EMEs than in AEs, and at the same time, domestic

[6]Table 3.A.3 shows the full results for the first stage regressions.

financial conditions, proxied by the lending interest rate, and domestic factors are more important in AEs.[7]

Table 3.3.2: EMEs vs. AEs

Independent Variable	Real investment $I_{i,t} - I_{i,t-1}$			
	(1)	(2)	(3)	(4)
	EMEs baseline	AEs baseline	EMEs infl. & outfl.	EMEs compon.
Net inflows (% of GDP)	0.91***	0.42***		
Inflows (% of GDP)			0.67***	
Outflows (% of GDP)			-0.24	
Net FDI inflows (% of GDP)				2.11***
Net portfolio inflows (% of GDP)				0.44*
Net credit inflows (% of GDP)				0.87
Lag investment	-0.04	-0.11	-0.01	-0.06
GDP growth (per capita)	0.49**	1.55**	0.39*	0.34
Lending rate	-0.34*	-2.57***	-0.36**	-0.37**
Primary balance (% of GDP)	0.14	0.69***	0.11	0.12
Terms of trade	0.23***	0.06	0.22***	0.2***
VIX	-0.001	-0.07*	0.001	0.0007
Number of observations	587	452	587	587
Number of countries	34	26	34	34

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

R^2 is omitted because it lacks informative contents in the IV estimation.

Turning our attention to gross inflows and outflows, we find that inflows have a significant positive effect on investment in EMEs (third column in Table 3.3.2), while outflows do not affect investment significantly. This could indicate that foreign capital is more productive than domestic one, as it may also involve inflows of know-how and even human capital. All other estimates remain similar to those from the

[7] Our results are robust to other indicators for domestic financial condition, e.g. the policy interest rate and credit to the private sector. See the appendix for those results.

baseline. Finally, column (4) shows the results when we study the components of net capital inflows collectively. We find, as do Mody and Murshid (2005) and Mileva (2008), that FDI and credit affect domestic investment significantly, while portfolio flows do not. The stronger effects of FDI, and to a lesser extent the effects of portfolio flows, can be attributed to the fact that direct investors may have a more detailed knowledge of the host country's economy and the specific sector in which they are investing. At the same time, direct investors, in contrast to international creditors and even portfolio investors, potentially gain control of the business in which they are investing. This perhaps also involves the implementation of foreign technologies and the transfer of know-how. Again all other coefficient remain quantitatively similar to the estimates of the baseline specification.

As explained above, we are also interested in gross FDI, portfolio and credit flows. Thus, we estimate a version of Equation 3.1, where we include gross in- and outflows of the different subcategories. The results are presented in Table 3.3.3. The first column shows the effects of gross FDI flows. We find that a one percentage point increase in FDI inflows increases domestic investment by 2.34 percent, while an increase in outflows decreases it significantly by 2.32 percent. Moreover, we find that portfolio inflows increase in domestic investment significantly, while outflows do not. Finally, credit inflows also increase domestic investment significantly, and outflows decrease it, but the magnitude of the effect of inflows is higher. Thus, we also see in these last two cases that foreign capital indeed has a stronger effect on investment.

However, the focus of our analysis is the differences between the effects of capital flows in EME and AEs. After understanding that net capital inflows have a larger effect on impact on investment in EMEs, while domestic conditions seem to be more important in AEs, we want to understand the dynamic effects of capital flows. For that purpose, we estimate Equation (3.1) fot $h = 0, ..., 4$ and compute the cumulative response of investment to a one percentage point increase in net capital inflows in EMEs and AEs separately. Figure 3.3.1 presents the impulse responses constructed using LP-IVs. Net capital inflows increase investment in EMEs on impact, reaching a peak after one year. The response is still significant up to two years after the initial increase in net capital inflows. In AEs, the rise in investment resulting from an increase in net capital inflows is small and is significantly different from zero only on impact. The differences between these two different groups of countries is significant and striking: capital flows have much stronger and longer lasting effects in EMEs.

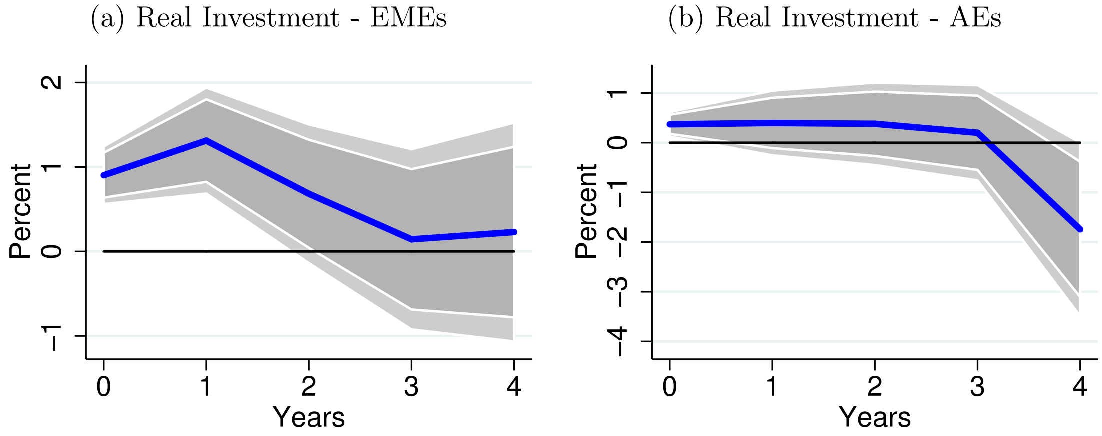
Table 3.3.3: Gross inflows and outflows: FDI, credit and portfolio

	Real investment $I_{i,t} - I_{i,t-1}$		
Independent Variable	(1)	(2)	(3)
	EMEs FDI	EMEs credit	EMEs portfolio
FDI inflows (% of GDP)	2.34***		
FDI outflows (% of GDP)	-2.32***		
Portfolio inflows (% of GDP)		1.72**	
Portfolio outflows (% of GDP)		1.34	
Credit inflows (% of GDP)			1.37***
Credit outflows (% of GDP)			-0.65***
Lag investment	-0.05	-0.03	-0.07
GDP growth (per capita)	0.32	0.54**	0.31
Lending rate	-0.39**	-0.35**	-0.42***
Primary balance (% of GDP)	0.08	0.08	0.09
Terms of trade	0.17***	0.24***	0.17***
VIX	-0.008	0.04	0.008
Number of observations	591	587	587
Number of countries	34	34	34

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

R^2 is omitted because it lacks informative contents in the IV estimation.

Figure 3.3.1: Real Investment response to a one percentage point increase in net capital inflows



Note: The figure shows the estimated cumulative impulse responses of real investment to a one percentage point increase in capital flows. Panel (a) shows the response in EMEs and panel (b) shows the response in AEs. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

3.4 Country characteristics, capital flows to EMEs and AEs and the domestic financial sector

3.4.1 Data examination

The clear differences in the IRFs and in the estimated coefficients for the lending rate suggest that in EMEs capital flows play a more important role for investment, while in AEs domestic financial conditions seem to be more important. Next, we inspect the data for net capital inflows in AEs and EMEs, as well as at domestic credit, in order to have a more detailed understanding of our results. We can see a much larger share of GDP of net inflows in EMEs compared to AEs (see Figures 3.4.1 and 3.4.2).

Figure 3.4.1: EMEs and DCs: Net Inflows as % of GDP (average 1999-2018)

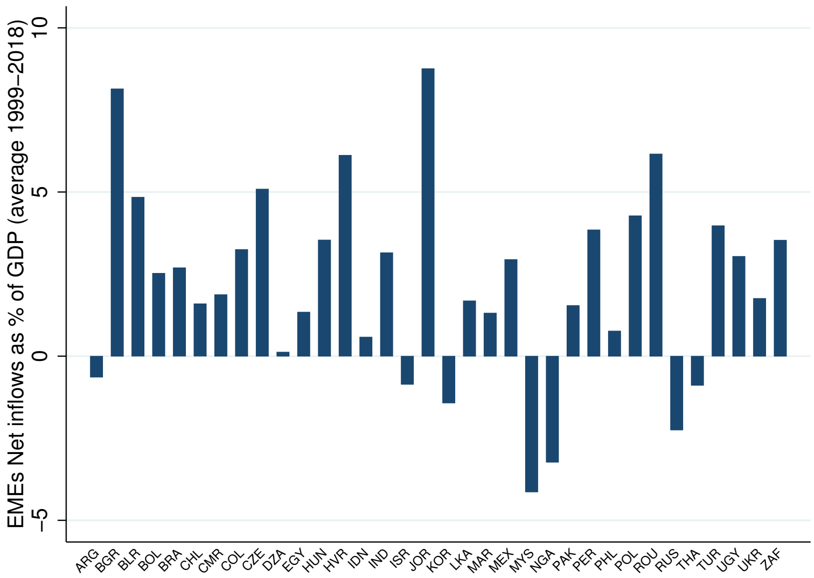
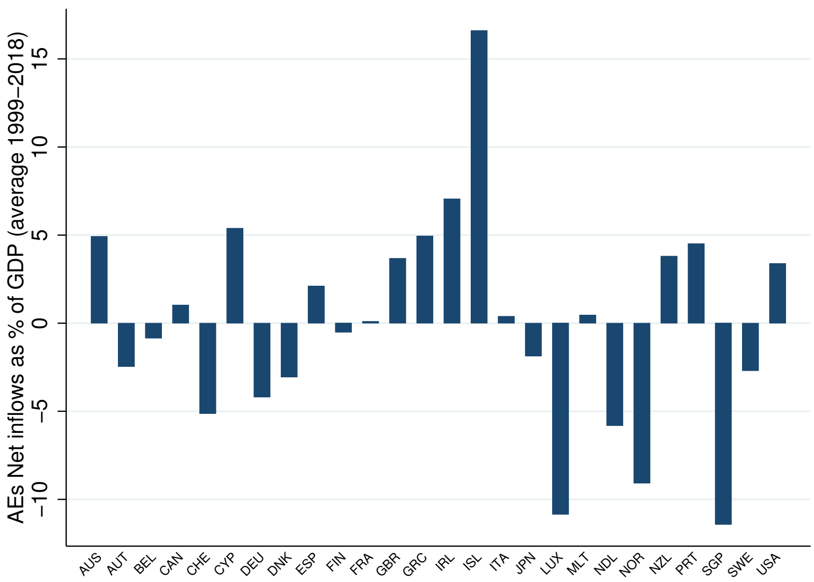


Figure 3.4.2: AEs: Net Inflows as % of GDP (average 1999-2018)



In addition, the domestic credit to the private sector as a fraction of GDP is much smaller for EMEs than for AEs, which may result in a higher dependency of firms on international creditors since available financial assets may not always be available from domestic creditors (see Figures 3.4.3 and 3.4.4). These comparisons suggest that, in EMEs, funding to domestic firms is more often granted by international investors. Another way to understand the dependency of local investment on foreign creditors is to look at domestic credit in relation to international capital flows. Again, we find that the domestic credit market is much larger and important in AEs than in EMEs (see Figure 3.4.5).

Figure 3.4.3: EMEs: Domestic credit to the private sector as % of GDP (average 1999-20168)

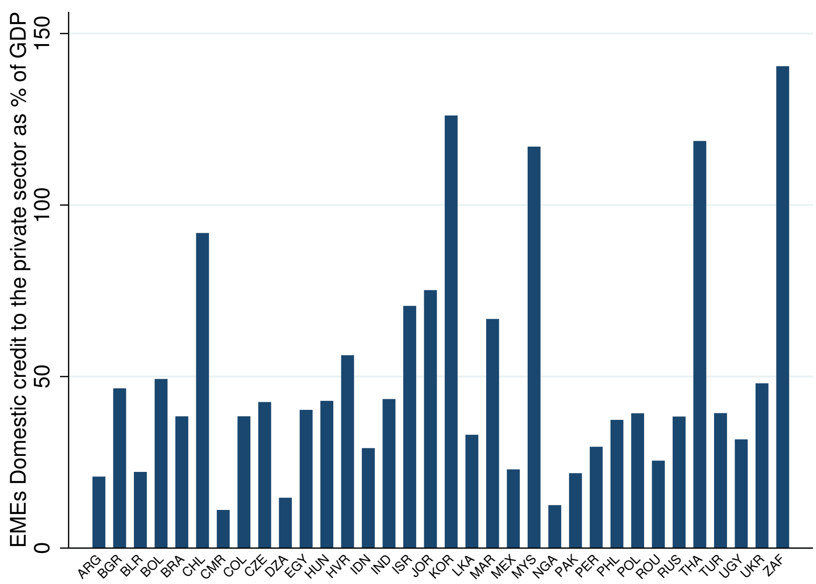


Figure 3.4.4: AEs: Domestic credit to the private sector as % of GDP (average 1999-2018)

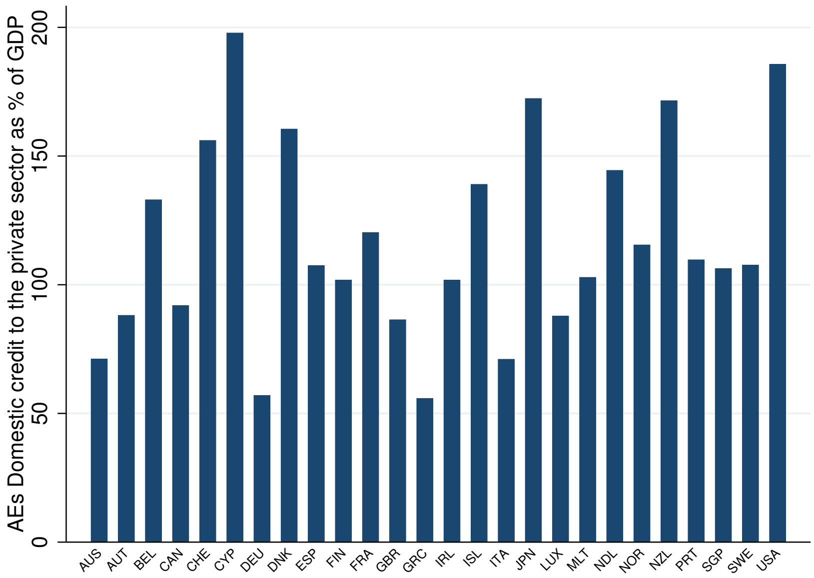
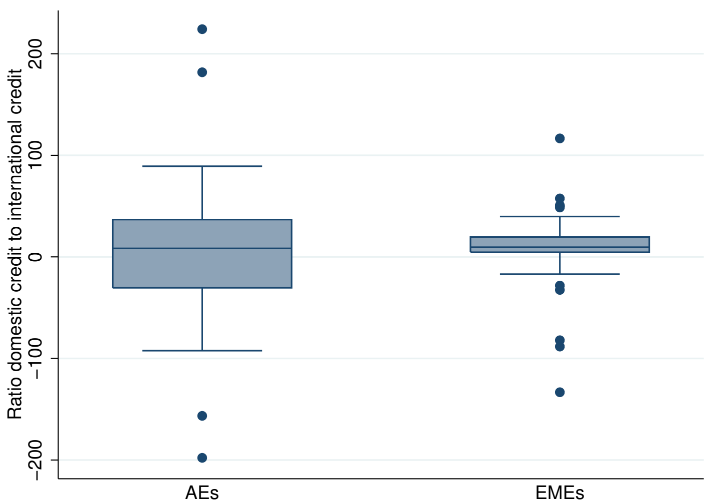


Figure 3.4.5: Ratio domestic credit to international credit (average 1999-2018)



3.4.2 What accounts for the differences?

We aim to understand what accounts for the differences between EMEs and AEs, specifically those in the impact of capital flows on investment. As we showed before, capital flows seem to be more important in EMEs while domestic financial conditions, i.e. lending rate, in AEs. One possible explanation is that international capital is more productive and therefore has a stronger impact on investment in countries where it is relative scarce, i.e. where its marginal product is higher. We can further argue, that capital is more productive in countries that are relatively poor, as they have less capital than relatively rich countries. Figures 3.4.6 and 3.4.7 show GDP per capita in the countries in our sample. As EMEs are poorer than AEs, this explanation possibly accounts for our earlier results: capital flows have a stronger impact on investment in EMEs, maybe because EMEs are poorer, thus in those countries the marginal product of capital flows is larger.

Figure 3.4.6: EMEs: GDP per capita PPP (average 1999-2018)

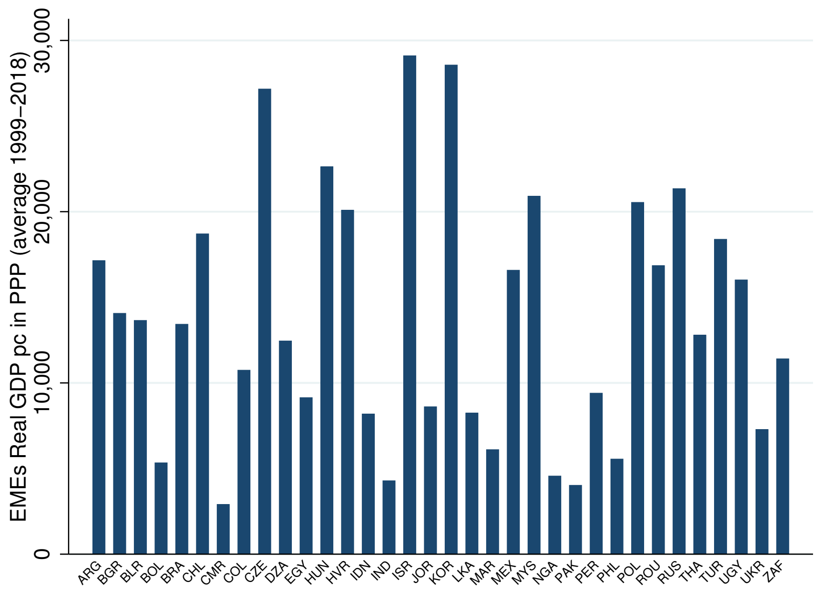
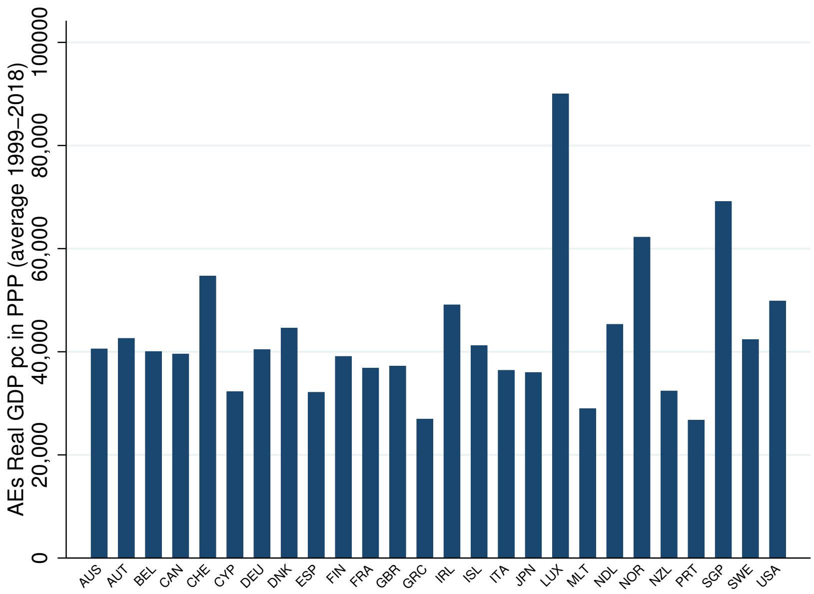


Figure 3.4.7: AEs: GDP per capita PPP (average 1999-2018)



Moreover, our results could also be explained by the differences in financial development between EMEs and AEs. As we can see in Figures 3.4.8 and 3.4.9, the IMF' financial development index is generally lower for EMEs, i.e. their financial sectors are less developed and thus EMEs may be forced to rely more heavily on foreign sources of funds for investment.

In order to test which of the two possible explanations accounts for the differences between EMEs and AEs, we exploit the inter and intra-group heterogeneity in the countries. As we saw above, AEs and EMEs differentiate themselves in GDP per capita and financial development, among other characteristics.[8] Moreover, we see in Figures 3.4.6 - 3.4.9, the AEs in our sample does not have large intra-group differences in GDP per capita and financial development. At the same time, we see that EMEs are very heterogeneous in those respects. For instance, our group of EMEs has more variability in the data with GDP per capita ranging from around 5,000 USD in some cases to almost 30,000 USD. Thus, due to the lack of variance in the AEs, we only can test our two candidate explanations in the group of EMEs, for

[8]In the analysis below, these other characteristics will be captured to certain extent by country fixed effects. However, their careful analysis is important, and is one of the next steps in this research project.

which we assess whether the effect of capital flows on investment in richer and/or more financially developed EMEs differs from the responses in poor and/or less financially developed EMEs. This will shed light on which of these two explanations account for the results above.

Figure 3.4.8: EMEs: Financial Development Index (average 1999-2018)

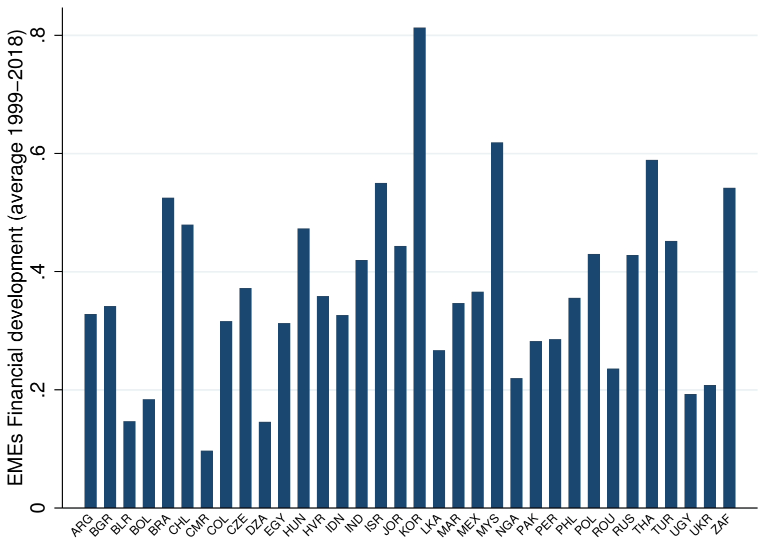
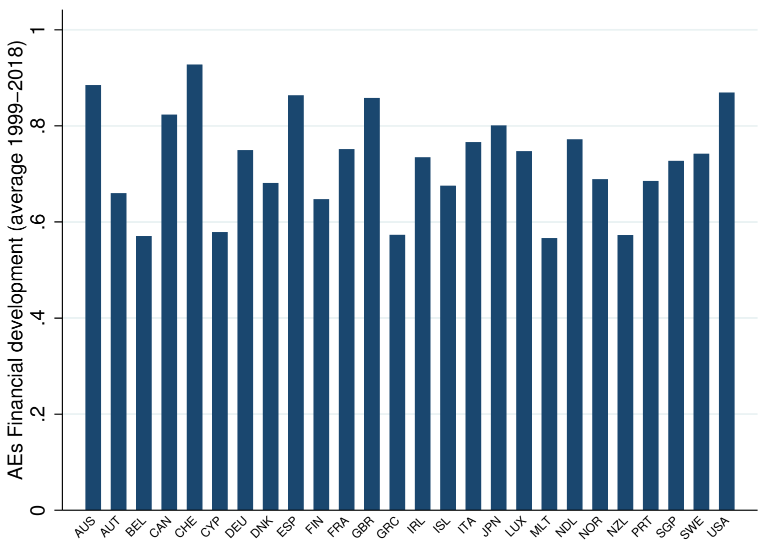


Figure 3.4.9: AEs: Financial Development Index (average 1999-2018)



Thus, we exploit the heterogeneity of countries in our sample of EMEs, and re-estimate Equation (3.1) adding a dummy that controls for the relative wealth of a country and a dummy that controls for the relative development of its financial system. Moreover, as a robustness check and to rule out other possible explanations, we also add dummies that control for a country's external vulnerability (see Iacoviello and Navarro, 2019) and capital account openness (see Chinn and Ito, 2006). We construct the first dummy in the following way: it equals one when a country's mean GDP per capita in PPP terms in the period analyzed terms is above the median in EMEs, and it equals zero when it is below. Similarly, the dummy for financial development equals one when a country's mean IMF's financial development index between 1999- 2018 is above the cross-country median and zero when it is below. We build the other dummies in the same way. We then interact these dummies with the capital flows variables, and if, e.g., a country's relative wealth is the key determinant of the strength of the effects of capital flows on investment, then we would see that in relatively richer EMEs, capital flows have a smaller effect on investment. By contrast, if domestic financial development is the main driver of our results above, we would see that in EMEs with more developed financial sectors the effect of capital flows is smaller than in the other group. Understanding whether there is a difference between richer and poorer EMEs and/or EMEs with more and less developed financial sectors, would shed light on what determines the strength of the impact of capital flows on investment, and also would indirectly account for the differences between AEs and EMEs.

Table 3.4.1 reports the results. Column (1) shows the results when we include the dummies and interaction terms for GDP per capita and financial development. The coefficient for the interaction between net capital inflows and GDP is negative, i.e. the impact of net capital inflows on investment is smaller in rich EMEs. However, this effect is not significantly different from zero. Next, we see that the interaction between net capital inflows and the dummy for financial development is negative, i.e. the impact of capital inflows is smaller in EMEs with more developed financial sector. The value of the estimated coefficients of the other controls remain similar. Column (2) shows the results of the estimation when we include interaction variables for other possible determinants of the impact of capital inflows on investment, such as external vulnerability or financial openness. The main message from column (1) remains and we observe only a significant effect of financial development.

Table 3.4.1: Net capital flows: country characteristics

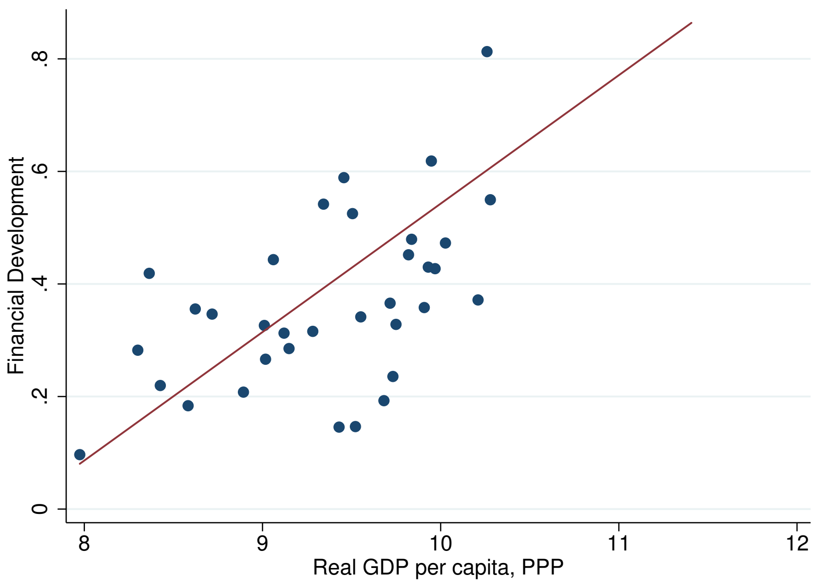
	Real investment $I_{i,t} - I_{i,t-1}$		
Independent Variable	(1)	(2)	(3) Orthog.
Net capital inflows (% of GDP)	1.37***	1.62***	1.11***
Net capital inflows × GDP per cap.	-0.31	-0.17	-0.22
Net capital inflows × financial dev.	-0.74***	-0.84***	-0.41*
Net capital inflows × vulnerability		-0.17	
Net capital inflows × financial open.		-0.29	
Lag investment	-0.06	-0.05	-0.03
Real GDP	0.54**	0.54**	0.46**
Lending rate	-0.34*	-0.34**	-0.34**
Primary balance (% of GDP)	0.14	0.13	0.11
Terms of trade	0.23***	0.24***	0.23***
VIX	-0.003	-0.003	-0.002
Number of observations	587	587	587
Number of countries	34	34	34

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

R^2 is omitted because it lacks informative contents in the IV estimation.

However, these results may be misleading, since there is a positive correlation between financial development and GDP per capita (see Figure 3.4.10). This is expected, as it is reasonable to think that rich countries have indeed more developed financial sector, or that high financial development may foster GDP growth. Thus, we need to disentangle these two effects to be able to attribute the corss-sectional defferences on one of them. To do so, we regress the financial development index on lagged GDP per capita, and we compute the resulting errors. They should be free from the the effects of GDP, thus we build our dummy for financial development based on this transformation. We do the same for GDP per capita: we regress it on the lagged financial development index, and the resulting errors should be free of the effect of financial development. Again, we build the dummy for the level of GDP per capita based on this. Column (3) shows the results of the estimation using these orthogonalized dummies. Even though the coefficient of financial development is smaller, it is still significant. This strongly suggest that financial development is what accounts for cross-country differences in the effects of capital flowson investment.

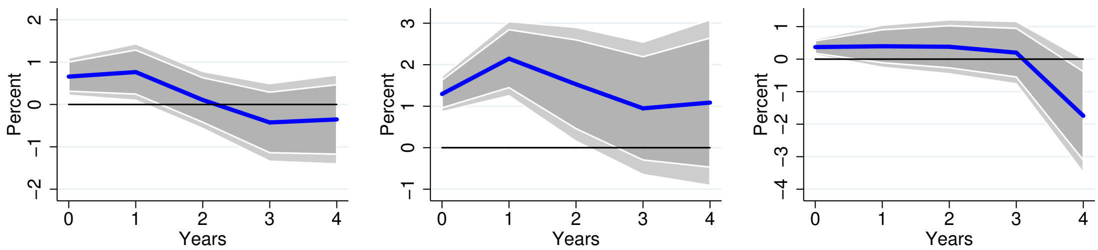
Figure 3.4.10: EMEs: Real GDP per capita and the Financial Development Index



After understanding that financial development is potentially the main driver between cross country differences in the EMEs, and thus perhaps accounts for the differences between EMEs and AEs, we estimate the response of investment to a one percentage point increase in net capital inflows. To understand the role of financial development, we split our sample of EMEs in two groups: those with high financial development (Figure 3.4.11 panel a) and those with low (panel b), and estimate Equation (3.1) for $h = 1, ..., 4$ and for each group. For completeness sake, panel (c) of Figure 3.4.11 shows the response of AEs, also shown in Figure 3.3.1.

Figure 3.4.11: Real Investment response to a one percentage point increase in net capital inflows

(a) EMEs: High Financial Development (b) EMEs: Low Financial Development (c) AEs



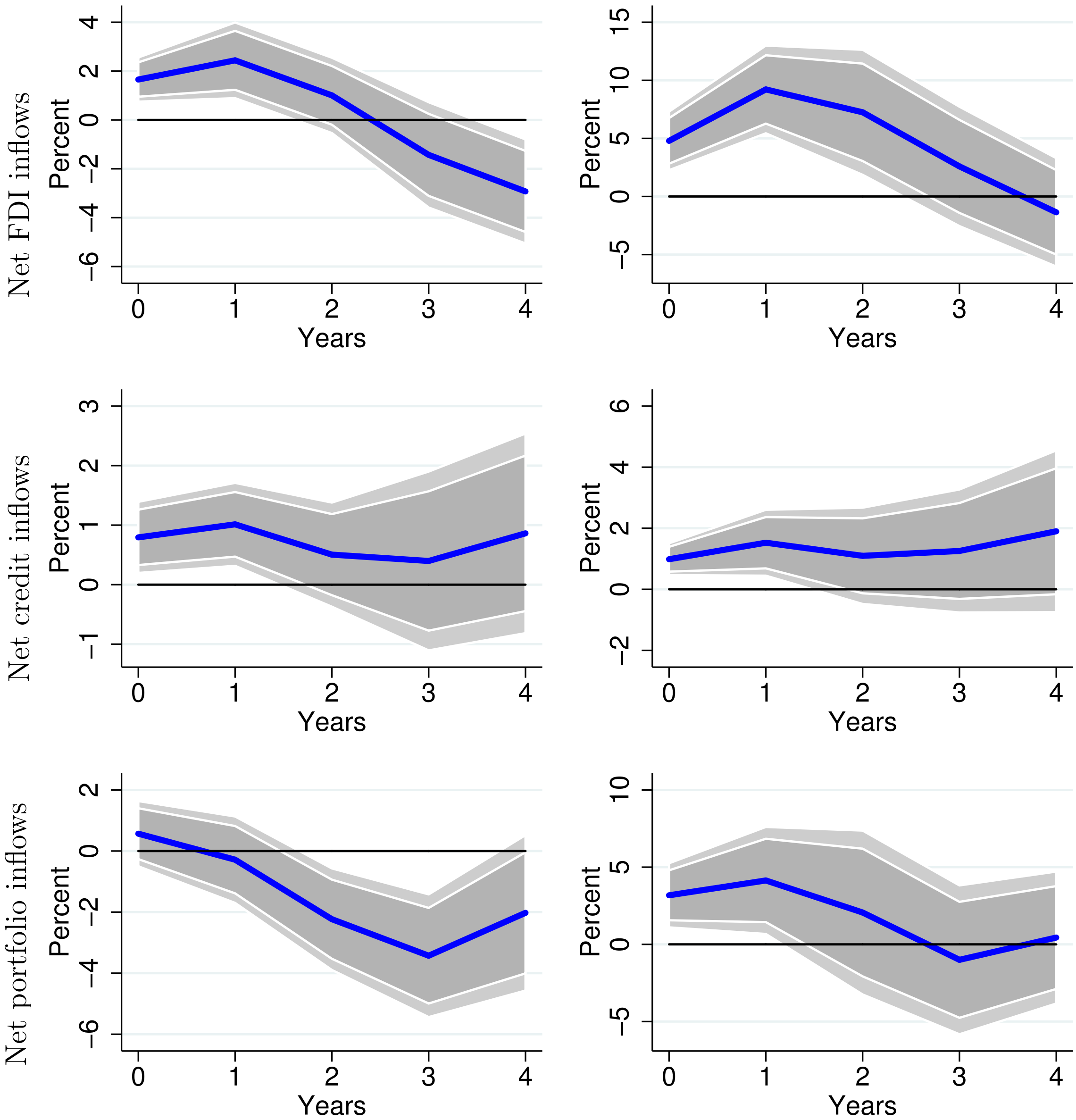
Note: The figure shows the estimated cumulative impulse responses of real investment to a one percentage point increase in capital flows. Panel (a) shows the response in EMEs with high financial development, panel (b) shows the response in EMEs with low financial development, and panel (c) shows the response in AEs. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

The response of investment in EMEs with high financial development looks very similar to the response in AEs: a one percentage point increase in net capital inflows increases investment by around half a percent on impact. The response is short-lived and the effect disappears after just one year. In EMEs with low financial development investment increases by over one percent on impact, the response is significant for a longer time, reaching a peak after one year and fading out after two years. This means that capital flows have a weaker impact on investment EMEs with high financial development. This suggests that financial development account for the differences between AEs and EMEs. As mentioned before, one possible explanation for this result is that the private sector in EMEs relies more heavily on foreign sources of financing, due to the less developed domestic financial markets. In this sense, international capital flows act as a substitute for perhaps more expensive and less accessible domestic funds.

Figure 3.4.12: Real Investment response to a one percentage point increase in the components of net capital inflows

(a) EMEs: High Financial Development

(b) EMEs: Low Financial Development



Note: The figure shows the estimated cumulative impulse responses of real investment to a one percentage point increase in capital flows. Panel (a) shows the response in EMEs with high financial development, panel (b) shows the response in EMEs with low financial development, and panel (c) shows the response in AEs. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Next, Figure 3.4.12 repeats the same exercise but focuses on the effects of the different types of flows. The first row shows investment's response to an increase in net FDI inflows, the second row the response to net credit inflows and the last row the response to portfolio inflows. Again, panel (a) corresponds to countries with high financial development and panel (b) to EMEs with low financial development. These results confirm out earlier insights: it appears that the degree of financial development accounts for cross country differences in the effect of capital flows on investment. Financial development affects specially the effect of FDI, which in turn is the component of capital flows that has the largest impact on investment (see also Tables 3.3.2 and 3.3.3). Again, these results point to financial development as a key driver of the cross-country differences.

3.5 Conclusion

In this paper we investigated how capital inflows and their different subcategories, i.e., foreign direct investment (FDI), portfolio flows and credit, affect domestic investment, which is an important indicator for medium-term economic development. We compared the results for EMEs with those for AEs. Our estimations showed that investment in EMEs is more dependent on international capital flows than those in AEs. Moreover, changes in investment in EMEs depend on variations in net FDI and portfolio inflows. We found indications that the difference in the effects of capital flows in EMEs and AEs is linked to the differences in financial development. Specifically, we found that investment in EMEs with high financial development respond to increases in capita flows the same way as AEs do. At the same time, EMEs with lower financial development experience strong increases in investment after an exogenous increase in (net) capital inflows.

Our results have several implications for policy makers. First, we found that FDI inflows have a very strong positive impact on investment in EMEs. Thus, policy markers may be interested in generating the tight conditions to attract this type of flows. Moreover, the fact that EMEs with low financial development experience a stronger effect of capital flows on investment, also suggests that these countries may be more prone to suffer the adverse effects of capital flow reversals or sudden stops.

Thus, policies aimed at granting a better access to domestic financing may isolate EMEs from volatile global financial conditions.

However, since this essay is work in progress, we still have to address several issues. For instance, we do not have a clear, structural explanation why financial development weakens the effects of capital flows on investment. Moreover, we have not explored other potential factors that could affect the international capital flows - investment relation, such as institutional quality, quality of policies (Mody and Murshid, 2005), exchange rate arrangements and competitiveness, or cross-industry differences in access to domestic and foreign finance and to foreign markets (Igan et al., 2016). Finally, we have pointed out that domestic credit conditions appear to matter more for AEs than for EMEs. To explore this important issue in detail, and to have a better and more robust analysis, we need to address the possible reverse causality between investment and domestic financial conditions. In this paper, we address this issue by using the lag of the lending interest rate. This analysis may possibly benefit from identifying domestic credit supply shocks to explore this point in a structural way. Thus, this essay's conclusions should be taken carefully.

Appendix

3.A Data and sources

Table 3.A.1: Data construction and sources

Variable	Construction and source
Real Gross Fixed Capital formation	Domestic currency, logarithm Source: World Development Indicators.
Net capital inflows	capital inflows - capital outflows (depending on the type we use either PDI, loans or portfolio flows), as % of GDP Source: International Financial Statistics, IMF.
Gross capital flows	Either FDI, loans or portfolio flows (equity + bond flows), as % of GDP. Source: International Financial Statistics, IMF.
Real GDP	Domestic currency, logarithm Source: World Development Indicators.
Real GDP per capita	PPP Source: World Development Indicators.
VIX	Option-implied volatility index. Source: Chicago Board Options Exchange, retrieved from St. Louis FRED.
Lending interest rate	Percent. Source: International Financial Statistics, IMF.
Policy interest rate	As nominal short-term rate, we choose the monetary policy rate (exact definition depends on policy measures of the respective country ("target rate", "policy rate", ...). Percent. Source: Datastream.
Credit to the private sector	% of GDP. Source: Datastream, World Development Indicators.

Terms of Trade growth	Logarithm Source: Datastream.
Total Flows	Sum of capital flows to all countries of the same group minus the flows to each specific country Source: Own calculations based on the International Financial Statistics Dataset.
Regional Flows	Sum of capital flows to all countries of the same geographic region and country group minus the flows to each specific country Source: Own calculations based on the International Financial Statistics Dataset.
Financial Development Index	International Monetary Fund.
Financial Openness Index	Chinn and Ito (2006).
Vulnerability Index	Iacoviello and Navarro (2019)

Table 3.A.2: List of countries

Country group	
Advanced economies (AEs)	Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, United Kingdom, United States
Emerging market economies (EMEs) and developing countries (DCs)	Algeria, Argentina, Belarus, Bolivia, Bulgaria, Brazil, Cameroon, Chile, Colombia, Croatia, the Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Jordan, Korea, Sri Lanka, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine, Uruguay

Table 3.A.3: First stage regressions

Independent Variables	Capital flows or its components (as % of GDP)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	EMEs baseline	AEs baseline	EMEs inflows	EMEs outflows	EMEs FDI	EMEs portfolio	EMEs credit
Regional net inflows§	0.11*** (33.22)	0.04*** (13.01)					
Regional inflows§			0.11***(34)				
Regional outflows§				0.11*** (37.21)			
Regional net FDI inflows§					0.10*** (18.5)		
Regional net portfolio inflows§						0.11*** (29.49)	
Regional net credit inflows§							0.12*** (37.7)
Lag investment	0.07 **	0.59	0.003	-0.07**	0.03*	0.00	0.04**
Real GDP	-0.1	-1.39	0.074	0.16	0.01	0.008	-0.12
Lending rate	-0.011	0.40	0.016	0.02	0.022**	-0.012	-0.022
Primary balance (% of GDP)	-0.03	0.58	-0.04	-0.01	-0.006	0.002	-0.015
Terms of trade	-0.017	0.31	-0.007	0.008	0.01*	0.0003	-0.03
VIX	-0.0008	0.005	-0.0007	-0.0005	-0.001	-0.0006	0.0002
R^2	0.29	0.09	0.35	0.18	0.23	0.18	0.30
Number of observations	587	452	587	587	591	587	591
Number of countries	34	26	34	34	34	34	34

§ as % of GDP

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The F-statistics of the instruments are in parenthesis.

3.B Robustness

Table 3.B.1: Robustness: other proxies for domestic financial conditions

Independent Variable	Real investment $I_{i,t} - I_{i,t-1}$			
	(1)	(2)	(3)	(4)
	EMEs	EMEs	AEs	AEs
Net inflows (% of GDP)	0.86***	0.46***	0.94***	0.42***
Lag investment	-0.03	-0.15	-0.03	-0.1
Real GDP	0.60**	1.4**	0.60***	1.31*
Policy rate	-0.07*	-0.43*		
Credit to the priv. sector (% of GDP)			-0.17	0.2*
Primary balance (% of GDP)	0.14	0.49**	0.12	0.52***
Terms of trade	0.23***	0.03	0.22***	0.05
VIX	-0.007	-0.10**	0.04	-0.10***
Number of observations	591	453	591	587
Number of countries	34	26	34	34

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

R^2 is omitted because it lacks informative contents in the IV estimation.

CHAPTER 4

The Drivers of Public Debt: A Holistic Approach[1]

4.1 Introduction

Recent years have witnessed a rapid increase in public debt. In 2007, gross general government debt in advanced economies stood at around 70 percent of GDP; by 2013, it had risen to over 105 percent (IMF, 2014). The resulting concerns over sovereign debt sustainability have led to significant financial and economic disruption, and the optimal policy response to these elevated debt levels is a topic of controversy among policymakers and academics. The proximate causes of this rapid increase in debt are well know. Deep recessions reduced nominal GDP and caused primary balances to deteriorate; banking sector recapitalization forced steep changes in the debt level; and in some cases, sovereign bond yields spiked, increasing the cost of debt. But what is less clear is how these various drivers of debt interacted with each other to propagate or mitigate their eventual impact on the debt level. For instance, a shock to the marginal interest rate on sovereign debt, perhaps as a result of increased risk aversion will, ceteris paribus, leads to an increase in the debt-to-GDP ratio. But this spike in yields may also have a detrimental effect on real growth, which would worsen debt dynamics further. On the other-hand, the government may react to this increase in yields by undertaking fiscal consolidation, which would improve debt dynamics. The overall path of debt, especially over the medium term, is unclear. But gaining a deeper understanding of these dynamics is critical for assessing risks to sovereign debt sustainability.

[1] This chapter is based on a research paper that is joint work with Alex Pienkowski. A version of this chapter was published under the title "What Really Drives Public Debt: A Holistic Approach" as IMF Working Paper no. 137, Volume 15, 2015.

In this paper, we explore how the various drivers of sovereign debt - the primary balance, the interest rate, growth and inflation - interact with each other. At the core of this analysis is the standard debt dynamics equation:

$$d_t = d_{t-1}\frac{(1+i_t^e)}{(1+g_t)(1+\pi_t)} - pb_t$$

where d_t is the sovereign debt-to-GDP ratio; ${i_t}^e$ is the effective interest rate on sovereign debt; g_t is real GDP growth; π_t is inflation, calculated with the GDP deflator; and pb_t is the primary balance to GDP ratio. Using a structural vector auto-regression (SVAR) model, we consider how these components interact with each other in a holistic manner. In particular, we also assess the role of the monetary policy and exchange rate regimes, i.e. whether a country is in a monetary union, has a peg or lets its currency float freely. This choice is often cited as an important determinant of sovereign debt dynamics. It has been argued that an independent central bank may have better control over nominal GDP, greater access to seignorage revenues and is better able to prevent creditor runs - all of which should contribute to more stable debt. In this paper, we consider to what extent this indeed matters for debt dynamics.

The remainder of the paper is organized into four additional sections. Section 4.2 summarizes the relevant literature on this topic; Section 4.3 sets out the methodology used and describes the data; Section 4.4 presents the results; and the last section concludes and discusses potential extensions.

4.2 Survey of the Literature

As far as we are aware, this is one of the few papers to explore how the various components that drive debt interact with each other in a single unified SVAR framework. There are, however, several important strands of literature that look at specific interactions in this regard. These can be summarized into three main categories - i) the response of discretionary fiscal policy to the debt level and other variables; ii) factors that influence the interest rate on sovereign debt, with particular focus on the credit spread; and, iii) the significant literature on fiscal multipliers. Our methodological approach draws heavily from the literature to estimate the fiscal multiplier. Finally, we also explore the literature on monetary policy and debt.

Several papers find that governments tighten fiscal policy in response to higher debt. Using data on the U.S., Bohn (1998, 2005) show that, after controlling for the business cycle and temporary expenditure shocks (e.g. wars), the primary balance reacts positively to debt. This, he argues, provides evidence that U.S. sovereign debt does not follow a random walk but reverts to some steady-state level and therefore is sustainable. Abiad and Ostry (2005) use a similar methodology, but with a panel of emerging markets. When controlling for additional factors, such as commodity prices and the quality of institutions, they also find that the primary balance reacts to stabilize debt. Also focusing on emerging markets, Mendoza and Ostry (2008) find a non-linear relationship between the primary balance and debt. At low debt levels, the primary balance responds positively to debt, but at higher debt levels, this response diminishes. One explanation for this is that sovereigns suffer from fiscal fatigue whereby they cannot increase the primary balance beyond certain levels.

A number of models assume that the market interest rate on sovereign debt increases with the debt level, but identifying this channel is difficult. Ceteris paribus, one would expect the interest rate on sovereign debt to increase as debt rises, as both the willingness and ability of governments to honor their debt obligations should decline. But finding an empirical relationship between the two has been difficult. This is because the sovereign's ability to repay is an important omitted variable. Corsetti et al. (2014) model sovereign default as a function of the distance to a debt limit - a point where debt is so high that a sovereign is no longer able or willing to service it. As agents are forward looking, this affects market interest rates in a non-linear fashion. Ghosh et al. (2013) combine a non-linear fiscal reaction function with a similar debt limit concept. Here interest rates are a function of both the debt level and ability to repay. The paper uses this methodology to calculate the fiscal space of individual countries. Controlling for sovereign debt is important when estimating the size of the fiscal multiplier. In their seminal paper, Blanchard and Perotti (1999) use a structural vector auto-regression (SVAR) model to estimate the size of the U.S. fiscal multiplier. They use out-of-model estimates of automatic stabilizer elasticities in order to identify the impact of changes in taxes and spending on growth. This technique has been used by many subsequent studies, including this paper. Favero and Giavazzi (2007) introduced the debt level as a fully endogenous component of this system. They argue that this is important for two reasons. First, fiscal policy can react to debt, and so excluding this from the system introduces an important omitted variable bias. Second, it is important to track the evolution of debt to ensure that the results of the model do not imply unrealistic (i.e. explosive) debt paths. Closest to our study is the paper by Cherif and Hasanov (2018), who use a similar technique, but focus more on debt sustainability in the U.S. They find that positive shocks to growth have a significant impact on reducing debt, but shocks to inflation or fiscal consolidation are less effective at containing debt. This suggests that in some cases, austerity can be self-defeating.

The role of monetary policy in influencing debt sustainability has been a matter of debate in recent years. De Grauwe and Ji (2013) show empirical evidence that euro zone countries (without "stand-alone" central banks) are more susceptible to self-fulfilling liquidity crises. Krugman (2014) illustrates this point using a more generalized theoretical framework. By contrast, Hilscher et al. (2014) and Reis (2013) argue that the U.S. has little scope to reduce its debt burden through central bank generated inflation. The trade-off between default risk and inflation risk is illustrated in Reis (2013), although this paper also demonstrates how central banks can reduce the risk of multiple equilibria. Corsetti et al. (2014) develop a model that illustrates how central banks can tackle liquidity crises, but not solve solvency crises. The results of this paper suggest that monetary policy regime plays a crucial role in sovereign debt dynamics.

4.3 Methodology and data

4.3.1 Empirical model

Following Favero and Giavazzi (2007) and Cherif and Hasanov (2018), our empirical model is summarized by the two following equations:

$$Y_t = \sum_{i=1}^{k} AY_{t-1} + \sum_{i=1}^{l} \gamma d_{t-i} + u_t, \tag{4.1}$$

$$d_t = d_{t-1}\frac{(1+i_t^e)}{(1+g_t)(1+\pi_t)} - pb_t \tag{4.2}$$

where the Matrix Y_t includes the primary balance, real GDP growth, the inflation rate and the effective interest rate on sovereign debt, in that order, and u_t are reduced form errors. All of the variables included in Y_t are components found in the simple debt accumulation equation (Equation 4.2).[2] The lag lengths are $k = 4$ and $l = 1$. In regard to the interest rate $i_t{}^m$, we use the *marginal* rather than the *effective* rate. The reason for this is that the effective rate tends to be slow moving, as it is the weighted average of past borrowing costs. The marginal interest rate on new government borrowing is more responsive to changes in debt sustainability risks; and as such, is a more important signal for markets and governments, which will influence how they react. It is important to note that the marginal interest rate is not the monetary policy rate, but the rate on new sovereign borrowing (defined by average maturity).

Moreover, again following Favero and Giavazzi (2007) and Cherif and Hasanov (2018), we include the lagged level of the debt to GDP ratio as an exogenous variable in the SVAR. We do so because changes in debt have feedback effects with the primary balance and interest rates, which may amplify the effects arising from fiscal shocks. Thus, excluding debt could potentially lead to omitted variable bias. More importantly, we take into account the dynamics of debt while computing the impulse responses, thus we need to keep track of Equation (4.2).

Our empirical approach is as follows: first we estimate the reduce form VAR (Equation 4.1) using OLS. Since Equation (4.2) is an identity, we do not need to estimate it, but following Favero and Giavazzi (2007), we will use it to construct the IRFs. Then, in order to identify the shocks to the primary balance and the other determinants of debt, we use an AB-model (Lütkepohl, 2007), where the matrices A and B relate the reduced form errors to the structural shocks e_t in the following way:

[2]Equation (4.2) is also depicted in the introduction.

$$Au_t = Be_t,$$

The estimates derived in the A matrix are used to illustrate how each of these components interact with each other, both contemporaneously and through time. In order to identify the shocks, we follow Blanchard and Perotti (1999) and Cherif and Hasanov (2018) and impose the following restrictions:

$$A = \begin{pmatrix} 1 & \mu_{pb,g} & \mu_{pb,\pi} & \mu_{pb,i} \\ \alpha_{21} & 1 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 \end{pmatrix} \qquad B = \begin{pmatrix} \beta_{11} & 0 & 0 & 0 \\ 0 & \beta_{22} & 0 & 0 \\ 0 & 0 & \beta_{33} & 0 \\ 0 & 0 & 0 & \beta_{44} \end{pmatrix}$$

To transform the reduced form errors, u_t, into structural error terms, e_t, the A matrix imposes certain identification conditions. Following Blanchard and Perotti (1999), the μ terms are elasticities, which are estimated separately from this model. They represent the elasticity of the primary balance with respect to growth ($\mu_{pb,g}$); the elasticity of the primary balance with respect to inflation, and the elasticity of the primary balance with respect to the marginal interest rate. The first two components are forms of *automatic stabilizers*, while the third is assumed to equal zero (the government is assumed to be too slow to react to changes in the interest rate contemporaneously). These country specific elasticities are taken from Girouard and Andre (2005), although as discussed in Section 4.4, the results are not particularly sensitive to these values. The α coefficients are estimated, and are ordered in a way which is standard to the literature.[3]

To construct the IRFs we need to consider the endogenous debt accumulation equation, as Equation (4.1) includes debt as a lagged variable. As mentioned earlier, we can derive the evolution of debt from the endogenous variables included in Y_t. In the initial period, debt is taken at its existing level, and all of the variables in Y_t respond to this level by the coefficients estimated in the γ vector (Equation 4.1). The variables Y_{t+1} are then used to construct debt in the following period, using Equation (4.2). This process continues for all subsequent periods.

As discussed by Cherif and Hasanov (2018), the inclusion of the debt feedback equation implies nonlinear relationships among the variables. Thus, in order to take this into account, we compute the impulse responses as in Cherif and Hasanov (2018), similar to the generalized impulse responses by Pesaran and Shin (1998). The IRFs are constructed as the difference between the forecast of the model, summarized by Equations 4.1 and 4.2, with and without a given shock e_t, for h periods ahead, subject to some initial values[4] w_{t-1}:

$$IRF(Y_t; e_t, w_{t-1}, h) = \mathrm{E_t}\left(Y_{t+h}|e_t, w_{t-1}\right) - \mathrm{E_t}\left(Y_{t+h}|w_{t-1}\right), \text{for } h = 0,1,2,... \quad (4.3)$$

Moreover, we again follow Cherif and Hasanov (2018) and bootstrap the data to construct the bands and the median response in the following way: First, after the initial estimation of the original reduced form VAR, the residuals are resampled and used to compute new data. In a second step the VAR is re-estimated, the structural identification is performed and the different IRFs are computed. This last step is repeated 2000 times to obtain the bootstrapped distribution of the IRFs. From the distribution, we obtain the median IRF for each shock, and the 16% and the 84% quantiles which represent the confidence bands.

Further, it is important to note that the debt accumulation Equation (4.2) will only approximate the actual evolution of debt. Other factors, such as bank recapi-

[3]Aside from the primary balance, it is assumed that shocks to growth will contemporaneously impact inflation and interest rates; shocks to inflation will impact interest rates, but not growth; and shocks to interest rates will have no contemporaneous effect on growth or inflation.

[4]These initial values are the lags of debt included in the estimation of the empirical model.

talization (not included in the primary balance) or methodological changes to debt or nominal GDP calculations, will also affect debt-to-GDP. But these factors are not accounted for in Equation (4.2). However, Figure 4.3.1 shows that the approximation is very close, and should not bias the results in this analysis. Likewise, the relationship between the marginal and effective interest rate is defined with a second auxiliary equation. Given that Equation (4.2) uses the effective interest rate and Equation (4.1) uses the marginal interest rate, we need a second auxiliary equation to link the two. Following Caprioli and Momigliano (2011), we approximate the relationship between these two variables as follows:

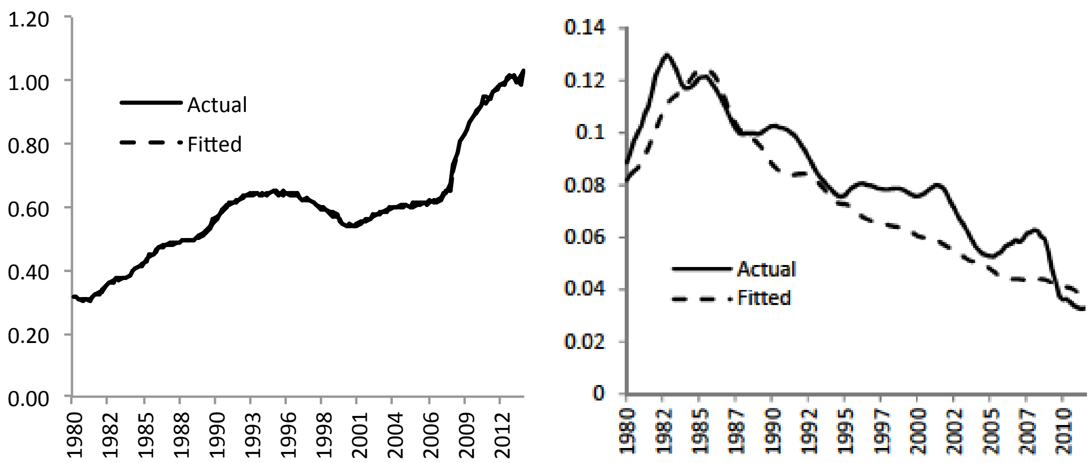
$$i_t^e = \frac{1}{2n_t} \sum_{j=1}^{2n_t} i_{t-j}^m \tag{4.4}$$

where n_t is the average maturity of the sovereign at time t. This, as with the debt accumulation equation, is also an approximation to the actual evolution of the effective interest rate. But as panel (b) of Figure 4.3.1 illustrates, the relationship is also close.

Figure 4.3.1: Actual and simulated data for the U.S.

(a) Actual and derived Debt-to-GDP

(b) Actual and derived Effective Interest Rate



Note: Panel (a) shows the actual and derived Debt-to-GDP ratio for the U.S. and panel (b) shows the actual ad derived Effective Interest Rate for the U.S.

4.3.2 Data

The data covers fifteen OECD countries (Australia, Canada, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Norway, Spain, Sweden, the United Kingdom and the United States), and was retrieved from several sources.[5] Most of the data covers the period 1999-2014 on a quarterly basis, however, depending on availability, we use longer time series for some countries.

4.4 Results

4.4.1 General patterns

The results consist of 375 different IRFs - 5 responses to each of the 5 different shocks over the 15 countries in the sample. Therefore, in order to make the results tractable to the reader, we present them in two formats. The first is a simple summary table, which draws out the median results derived from the estimates. The second is the standard IRFs, which we present to highlight specific differences within the sample. In regard to the former, Table 4.4.1 presents the results that we expect to find based on *a priori* economic intuition. In this table, the rows summarize four potential shocks imposed on the system - the primary balance, real growth, marginal interest rates and debt. The columns show how we expect the other variables to respond.[6] Each cell in the table shows the expected direction of the reaction.

[5] Sources: Eurostat, U.K. National Statistics Office, Federal Reserve Bank of St. Louis, Datastream, Haver, IMF debt database, OECD, DGO Portugal, International Financial Statistics, IMF Fiscal Monitor, U.K. debt management office, Bank of Italy.

[6] To simplify the illustration of the results, we do not include in this table the inflation shock and the potential response of inflation and growth. This is because most responses to shocks to inflation, as well as most of the responses of inflation to other shocks were not statistically different from zero. We exclude GDP growth since there is already a significant literature on the impact of growth from changes in the government balance and interest rates, and so this is not the focus of the paper.

Table 4.4.1: A priori Expectation of Economic Relationships

		Response		
		Primary Balance	Marginal Interest Rate	Debt to GDP ratio
Shock	Primary Balance (+)[1]	Shock	decrease	decrease
	Real Growth (–)[1]	unclear	increase	unclear
	Marginal Interest Rate (+)[1]	increase	Shock	unclear
	Debt to GDP ratio (+)[1]	increase	increase	Shock

[3]1 (+) refers to an exogenous increase, (–) refers to an exogenous decrease.

Take the example of a positive shock to the primary balance i.e. a shock that causes fiscal consolidation (first row). In this case, we expect the marginal interest rates to fall as markets may view this as increasing the ability of the government to repay its debts. We expect the debt to GDP ratio to decline as repayments increase and interest payments gradually fall. Next, assume a negative shock to growth. It is unclear, ex-ante, how a government might react - it may choose to pursue expansionary fiscal policies, in order to stimulate growth. Or it may choose to consolidate, in order to ensure that debt does not increase too significantly. The reaction of markets is, however, likely to be push up interest rates. This means the overall impact on debt is ambiguous.

Table 4.4.1 can, therefore, be viewed as a set of hypotheses that we test in this paper. As well as the direction of the response, we also investigate both the magnitude and persistence of these effects. By first considering the average response of all countries in the sample, our results may shed light on the hypotheses described above (Table 4.4.2). The IRFs used to construct this table are shown in the appendix.

The primary balance reacts actively to growth shocks and is highly sensitive to changes in the marginal interest rate. The response of the primary balance to growth shocks appears to be counter-cyclical, despite controlling for automatic stabilizers in the SVAR. This suggests that governments in the sample use active discretionary fiscal policy to help stimulate/suppress demand in the face of growth shocks - the peak response of a one percentage point fall in growth is a 0.6 percentage point

Table 4.4.2: Summary of all countries

		Response (median)		
		Primary Balance[3]	Marginal Interest Rate[3]	Debt to GDP ratio[3]
Shock	Primary Balance (+)[1]	1.00	0.04	-1.25
	Real Growth (−)[1]	-0.60	0.01	1.60
	Marginal Interest Rate (+)[1]	0.7	1.00	0.45
	Debt to GDP ratio[2] (+)[1]	2.1	-0.04	1.00

[3] (+) refers to an exogenous increase, (−) refers to an exogenous decrease.
[2] Debt is an auxiliary variable in this system, so we construct the responses to changes in debt as the difference of the solution of the model for h periods ahead from a ten-percentage points increase in debt, and the solution of the model without the increase in debt.
[3] Reflects the peak response to the shock.

loosening in the (structural) primary balance. The government reaction function also seems to be sensitive to the marginal interest on its debt. A one percentage point increase in the marginal rate leads to an average tightening of the primary balance of around 0.7 percentage points. This reaction may be explained by the governments' desire to stabilize debt in order to prevent interest rates increasing to unsustainable levels. This is followed by a loosening as the interest rate shock dissipates. Finally, the primary balance reacts to debt positively - a ten percentage points increase in debt, on average generates a 2.1 percentage points tightening in the primary balance. In summary, governments in this sample seem to actively react to shocks that impact debt dynamics - these responses are designed to stabilize debt, and thus mitigate the second-round effects of these shocks.

The estimated market reaction to these shocks does not match the economic a priori intuition summarized in Table 1. The market reaction to the primary balance, growth and debt shocks are close to zero. Part of this counter-intuitive result can be explained by factors, other than credit risk, driving long-term interests - most notably a decline in the long-term real rate associated with the crisis. However, as explored in greater detail below, this sample average hides more interesting and more intuitive cross-country differences.

The final column of Table 4.4.2 illustrates the peak impact on debt from each of the shocks and subsequent responses. The response of debt to these shocks is mechanical, through Equation (4.2). However, it is interesting and important to note that debt eventually stabilizes following each of these shocks. This means that while some of the responses act to exacerbate the impact on debt, the overall system does bring debt back to its pre-shock level. We explore these below, when we discuss specific country groups.

4.4.2 Splitting the sample

Within this sample average, there lies a number of interesting differences between countries. In this regard, we split the countries into two categories that seem to be important in determining differences in debt dynamics. The first category includes sovereigns that do not have full control over monetary policy, such as those in a currency union or have a fixed exchange rate regime. The second category includes sovereigns which have an unconstrained monetary policy regime, typically inflation targeters. There are a number of reasons why the presence of an independent monetary policy regime may be important for sovereign debt dynamics. First, country authorities can better control nominal GDP, therefore providing a mechanism to stabilize debt-to-GDP without resorting to fiscal consolidation. Second, a central bank can use seigniorage revenues to help repay debt (potentially at the expense of higher inflation). Third, large purchases of government debt (sterilized or unsterilized) can help "coordinate" creditors in order to avoid a run on sovereign debt i.e. the central banks can reduce the likelihood of multiple equilibria. The following section will explore how these two country groups (constrained and unconstrained monetary policy) react differently to various shocks to the components of debt. In each example, the median country IRF in each group is used to illustrate this relationship.[7]

4.4.3 The response of interest rates

The response of the marginal interest rate to shocks to the primary balance and growth is similar for both monetary policy regime groups. Panel (a) of Figure 4.4.1

[7] Countries defined as having constrained monetary policy in the sample include - Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy and Spain. Countries defined as having unconstrained monetary policy in the sample include - Australia, Canada, Norway, Sweden, the United Kingdom and the United States.

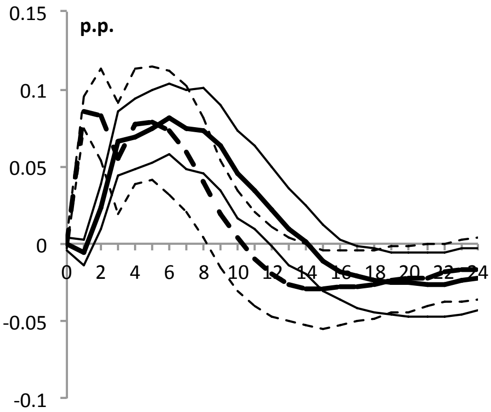
shows that a one percentage point exogenous deterioration of the primary balance generates a small increase in the marginal interest rate, for both groups, peaking at around 0.1 percentage points. This somewhat counter-intuitive result may be associated with correlation, or an unspecified common shock may be driving both fiscal consolidation and higher borrowing costs. The response of marginal interest rates to growth shocks is essentially insignificant for both monetary policy regime groupings (panel b of Figure 4.4.1). In summary, therefore, this evidence suggests that markets do not significantly react to changes in two key determinants of debt dynamics. This may be because shocks to these variables are often not viewed as being a threat to debt sustainability - they may only matter in times of crisis. In this regard, therefore, the debt level itself may be a more important determinant of the marginal interest rate.

The reaction of marginal interest rates to a shock to debt is more interesting (panel c of Figure 4.4.1).[8] Following an exogenous increase in the debt level (perhaps as a result of bank recapitalization costs), the marginal interest rate on the constrained monetary policy group increases sharply, and is persistent for around 1.5 years. This presumably reflects the market's perception that the credit risk for these sovereigns has materially increased. The gradual reduction in interest rates only occurs once debt has been stabilized, primarily through fiscal consolidation (see below). In contrast, the marginal interest rate seems to persistently *fall* for the unconstrained monetary policy group. This somewhat puzzling result *may* be attributed to how these country authorities use monetary policy in such circumstances. These countries may be able to manipulate long-term sovereign rates (perhaps through asset purchase facilities or forward guidance) in order to stabilize debt dynamics. Hence this could point to evidence that country authorities use monetary policy as a tool to stabilize debt dynamics. However, the modeling approach used here is not able to determine this hypothesis precisely given the reduce form nature of the estimation technique. And furthermore, it cannot determine whether such monetary policy

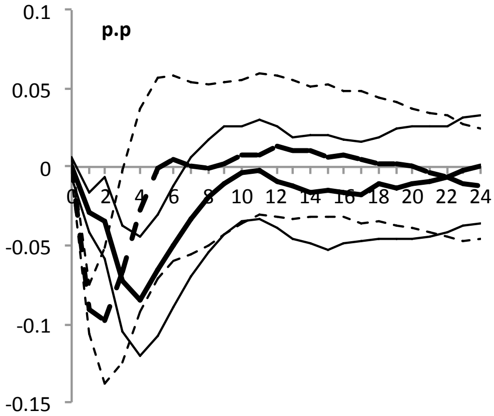
[8]Since debt is not part of the endogenous system, but is included as a predetermined (lagged) variable into the VAR model, we construct the responses to changes in debt as the difference of the solution of the model for h periods ahead from a ten-percentage points increase in debt, and the solution of the model without the increase in debt. We do not construct confidence bands for this exercise.

Figure 4.4.1: Responses of the Marginal Interest Rate to different shocks

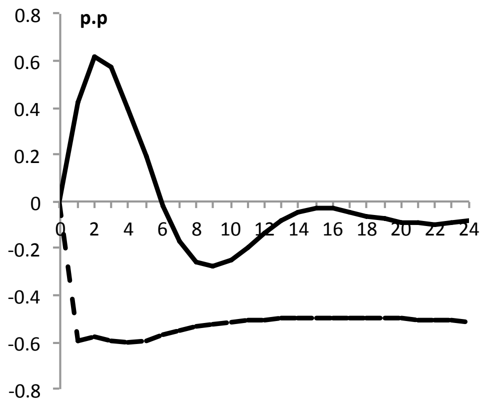
(a) Shock to the Primary Balance



(b) Shock to Growth



(c) Shock to Debt



Note: The continuous line shows the responses of the constrained countries and the dotted lines the responses of the unconstrained countries. The shocks are set to be a one percentage point increase in the primary balance (panel a), a one percentage point decrease in growth (panel b) and a ten percentage points increase in debt (panel c).

action is an *explicit* policy to help stabilize debt, or whether it is the *unintended consequence* of other monetary policy objectives.

4.4.4 The response of the primary balance

The response of the primary balance to a shock to the marginal interest rate is very different for the two groups. A shock to interest rates typically generates a large and persistent increase in the primary balance from countries without full control of monetary policy (panel a of Figure 4.4.2). This finding may be explained by the country authorities' perception that they are more vulnerable to a loss of confidence in their ability to control debt, and so react strongly to any increase in marginal borrowing costs. In contrast, there is virtually no reaction from countries with an unconstrained monetary policy regime. This may be because these countries are less concerned by a loss of confidence by markets; or because they perceive changes in interest rates as being attributed to other factors than an increase in the probability of default. For whatever reason, there is no systemic response of the primary balance for this group.

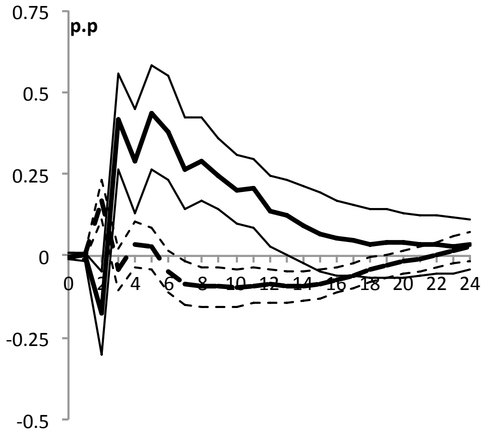
We find a similar pattern for the response of the primary balance to a negative shock to growth. Similar to the previous case, the (structural) primary balance does not react to shocks to growth for countries with unconstrained monetary policy (panel b of Figure 4.4.2). These countries can use monetary policy to counter demand shocks, and thus help to stabilize debt dynamics without needing to resort to fiscal consolidation. This is not the case for countries with constrained monetary policy. When these countries are hit by a growth shock, they need to pursue persistently tighter primary balance in order to stabilize debt dynamics. Put differently, these countries seem more vulnerable to growth shocks than countries with unconstrained monetary policy.

Both country groupings tighten fiscal policy in response to debt shocks, but the response from the constrained monetary policy group is much larger. Although the primary balance in countries with independent monetary policy may not react to growth and interest rates shocks, they typically will tighten fiscal policy in response to a shock to the debt level (Figure 4.4.2, panel c). This confirms the result of Bohn (1998, 2005) and others that the primary balance reacts proportionally to the debt level. This result is also found for constrained monetary policy group, but the response is significantly larger. This is perhaps not surprising given the results described above. These countries do not have full control over monetary policy to stimulate aggregate demand, and so must rely on more on fiscal tightening in order to stabilize debt - hence the larger response shown in panel (c) of Figure 4.4.2.

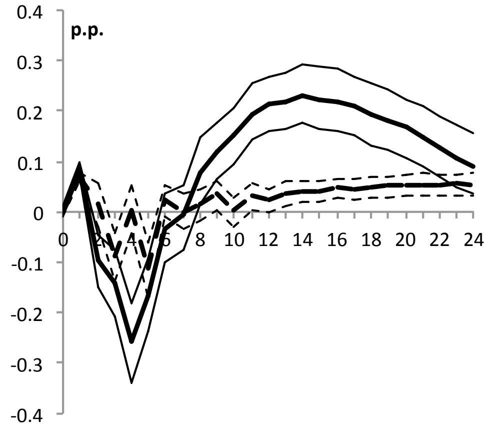
An important caveat to note is that most of the countries in the constrained group were also subject to fiscal rules imposed by the Euro area Stability and Growth Pact (SGP). This may have systematically influenced fiscal policy over this period.

Figure 4.4.2: Responses of the Primary Balance to different shocks

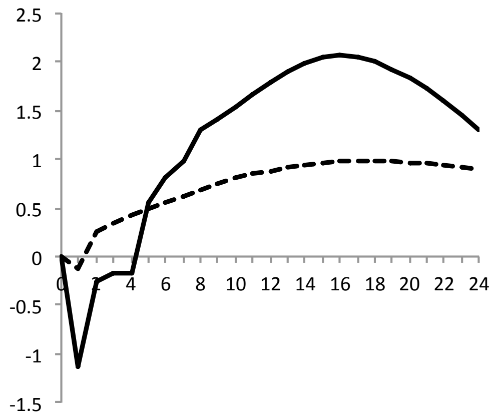
(a) Shock to the Marginal Interest Rate



(b) Shock to Growth



(c) Shock to Debt



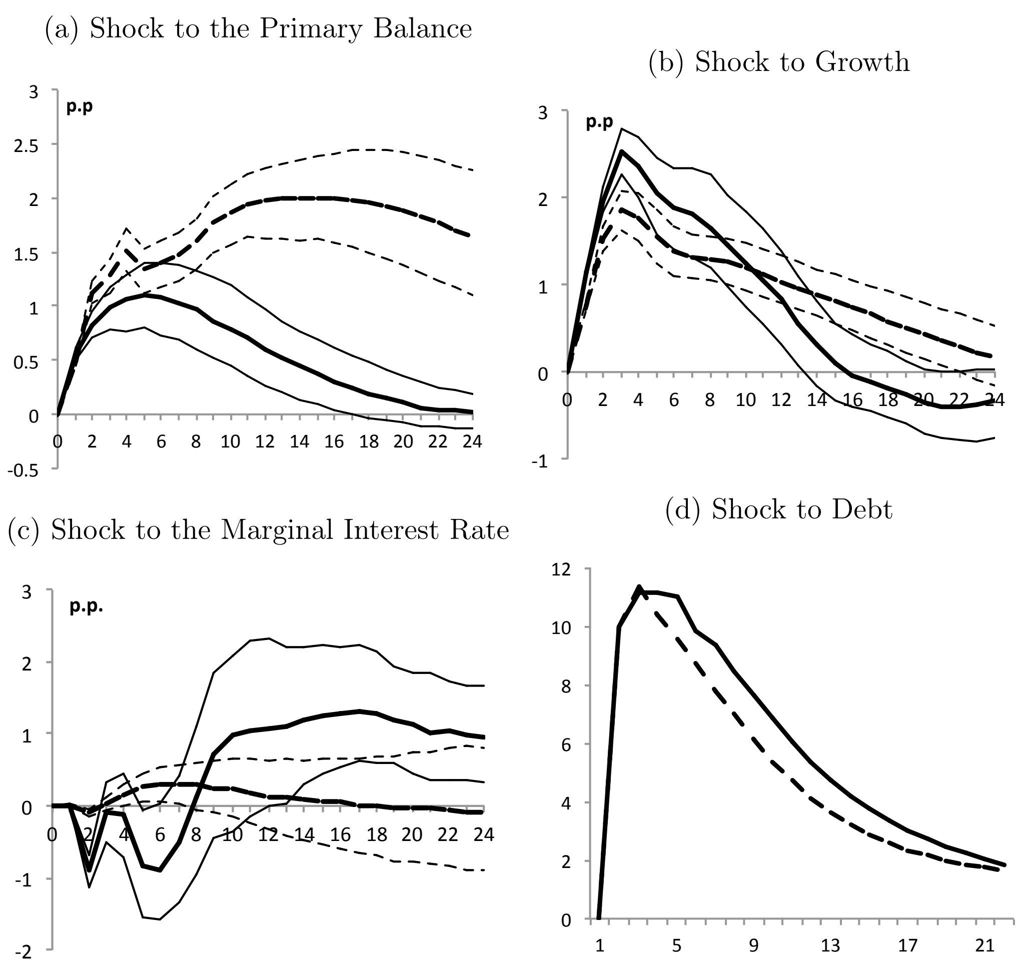
Note: The continuous lines shows the responses of the constrained countries and the dotted lines the responses of the unconstrained countries. The shocks are set to be a one percentage point increase in the marginal interest rate (panel a), a one percentage point decrease in growth (panel b) and a ten percentage points increase in debt (panel c).

Although this is not something that we can test directly in this framework, there are two factors that suggest that these rules are not driving these results. First, the SGP rules were broken on a number of occasions, so were not deemed binding on policy. Second, many countries in the unconstrained group - for example, the UK, USA and Australia - also had fiscal rules (see Budina et al. (2012)), but experienced fiscal policies that were very different to the constrained group.

4.4.5 The evolution of debt

In the final part of the results section, we explore how the various components of debt interact together to influence the overall trajectory of debt. While some relationships act to exacerbate the impact of shocks to debt, in all cases the debt level converges back to the pre-shock level. However, the deviation from the original debt level and the persistence of this impact differs significantly depending on the nature of the shocks and the monetary policy regime in place.

Figure 4.4.3: Responses of the Debt to different shocks



(a) Shock to the Primary Balance

(b) Shock to Growth

(c) Shock to the Marginal Interest Rate

(d) Shock to Debt

Note: The continuous lines shows the responses of the constrained countries and the dotted lines the responses of the unconstrained countries. The shocks are set to be a one percentage point increase in th primary balance (panel a), a one percentage point decrease in growth (panel b), a one percentage point increase in the marginal interest rate (panel c), and a ten percentage points increase in debt (panel d).

Debt takes significantly longer to return to pre-shock levels when countries with unconstrained monetary policy are hit with primary balance shocks (panel a of Figure 4.4.3). Considering a negative one percentage point shock to the primary balance, the peak impact on the debt level is 2 percentage points for countries with unconstrained monetary policy, and this impact is highly persistent. This suggests that these countries are able to maintain this higher debt level for a long period of time, only gradually reducing debt back to pre-crisis levels. Countries with constrained monetary policy react by reducing debt at a much quicker rate-perhaps because country authorities feel more vulnerable to debt at a more elevated level. Negative shocks to GDP generate a significant increase in the debt level for both country groups (panel b of Figure 4.4.3). The median debt levels increase by around 2-2.5 percent of GDP at the peak. The constrained group experiences a slightly larger peak impact on its debt level partly because the rising debt level causes a larger increase in marginal interest rates than the unconstrained monetary policy group. However, a stronger primary balance response causes the debt level to return to its pre-crisis level at a faster rate. The unconstrained group, in contrast, can afford to reduce its debt level at a more measured pace, perhaps because the risk of an adverse market reaction is less acute. Interest rates shocks matter very little for the debt of countries with unconstrained monetary policy (panel c of Figure 4.4.3). For these countries, the impact on debt quickly dies out. In contrast, the impact on the debt of an interest rate shock is highly persistent. panel d of Figure 4.4.3 shows how a 10pt increase in debt - perhaps as a result of the realization of some contingent liability - will persist through time. Both country groups show a similar response with debt returning to its pre-shock level after around 5 years. These responses, which appear similar, likely hide differences in the underlying dynamics. Countries with unconstrained policy have more scope to reduce debt by stimulating growth. In contrast, as seen above, those with constrained policy are more likely to resort to fiscal consolidation.

4.4.6 Diagnostics and robustness tests

All data series used in the estimation process are stationary. We tested for unit roots with the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The ADF test rejected the hypothesis of a unit root for most of the time series, especially for real GDP growth and inflation. In the cases in which the hypothesis of a unit root could not be rejected, we implemented the KPSS test. On this basis, we found four countries-Japan, Portugal, Austria and the Netherlands- with at least one non-stationary data series, so they were dropped from the sample. Therefore, we proceeded with the VAR analysis without major concerns about stationarity.

The model results are also robust to changes in the specification. Given the relatively small number of observations for each country, we changed the lag length to test whether this significantly altered the results. The results remained consistent - for instance, using a lag length of 2 (rather than 4) quarters did not change the results much and the IRFs maintained the same sign, and similar magnitude and statistical significance. The sample period (1999-2014) was a time of structural change in the euro area, which can be characterized into two episodes - i) the adoption of the euro which led to financial convergence with falling inflation and market interest rates; ii) the Euro area crisis, where market interest rates diverged significantly. In order to test how this influences the results, we restricted the sample to exclude the crisis years (2008-2014). For the countries where a longer time series is available (U.S., U.K.), there is no significant change in results. However, as expected, there are some differences for the other countries with shorter data series. In these cases, some have confidence bands that are wider and some shocks become insignificant. Given the shorter time series and that the crisis period witnessed a significant amount of debt dynamics activity, this is not surprising. The median debt level for the unconstrained group is slightly below that of the constrained group, over the sample period (panel a of Figure 4.A.1). However, the large variance in debt levels within these groups suggests that this should not introduce a systematic bias into the estimates. The SVAR identification technique is also varied. Using a Cholesky decomposition, rather than imposing the automatic stabilizer elasticities, also maintains the results as largely unchanged. Removing outliers countries (for instance, Norway with its large sovereign wealth fund) does also not materially change the results. On balance, therefore, the model is robust to altering the specification.

4.5 Conclusion

In this paper, we explored how the various drivers of sovereign debt - the primary balance, the interest rate, growth and inflation - interact with each other. The SVAR model that we used in this study includes an endogenous debt accumulation equation, which allowes us to incorporate debt feedback effects into these interdependencies. With this model, we gained a deeper understanding of how these relationships might act to exacerbate or mitigate the impact on debt following a shock to one of its components. The sample of countries is made up of 15 advanced economies, with differing monetary policy regimes. This choice of policy regime plays an important determinant in explaining cross-country differences in debt dynamics.

Our empirical results indicated that sovereign credit markets do not seem to systematically respond to shocks to growth or the primary balance but are sensitive to the debt level. For countries with constrained monetary policy, such as those in a currency union or with a fixed exchange rate regime, market interest rates react positively with the debt level - this increase presumably reflects a rise in credit risk. This is not the case for countries with unconstrained policy, where there is some evidence that higher debt may be associated with downward pressure on the long-term rate. This does not imply that advanced economies with unconstrained monetary policy do not need to be concerned with sovereign debt dynamics - only that these economies may have more tools at their disposal to tackle debt problems. This hypothesis is strengthened by the evidence that countries with constrained monetary policy are more reliant on fiscal adjustment to stabilize debt. These countries use fiscal policy to stabilize debt when faced with shocks to growth, the primary balance and the debt level itself. This is less pronounced for the unconstrained group, although some fiscal consolidation does seem to follow a shock to debt. These differences mean that the unconstrained group tends to bring debt back to its pre-shock level at a more measured pace.

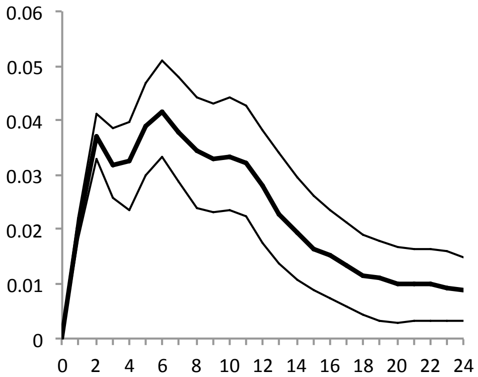
Our paper, therefore, provided some empirical evidence to support the often cited opinion that the exchange rate and monetary policy regime matters for sovereign debt sustainability. Our analysis also provided the basis to assess how a shock - say to growth - will impact debt dynamics directly and through second round effects (such as through the primary balance and interest rates). This is particular useful for debt sustainability analysis - both in terms of looking at the impact of adverse shock to the system and in terms of assessing the realism of baseline projections. This analysis could be extended in a number of useful directions. First, the analysis could be extended to emerging markets economies (where data is available) - this would likely require the addition of an exchange rate term into both the SVAR and auxiliary debt accumulation equation to control for foreign currency denominated debt. Papers by Adler and Sosa (2013) and Estevao and Samake (2013) provide useful analytical frameworks to support this type of extension. Finally, to overcome the curse of dimensionality that we face in this paper, Bayesian techniques could be used to estimate the SVAR.

Appendix

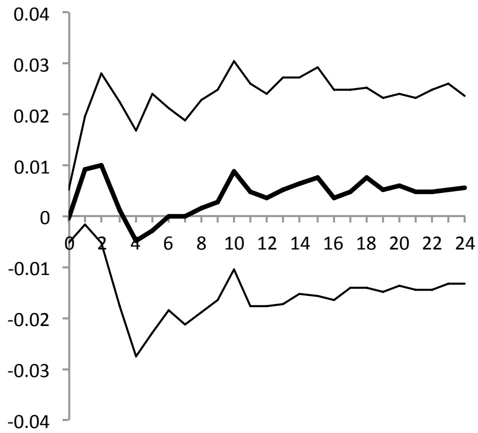
4.A Additional Figures

Figure 4.A.1: Responses of the Marginal Interest Rate to different shocks

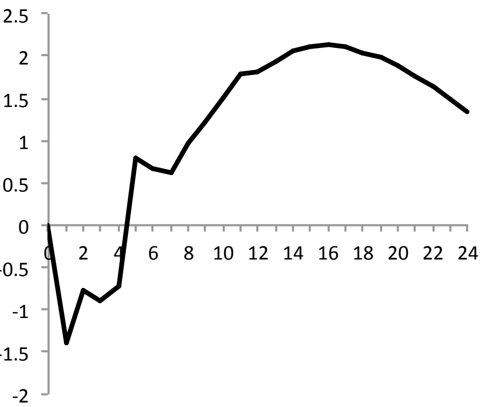
(a) Shock to the Primary Balance



(b) Shock to Growth

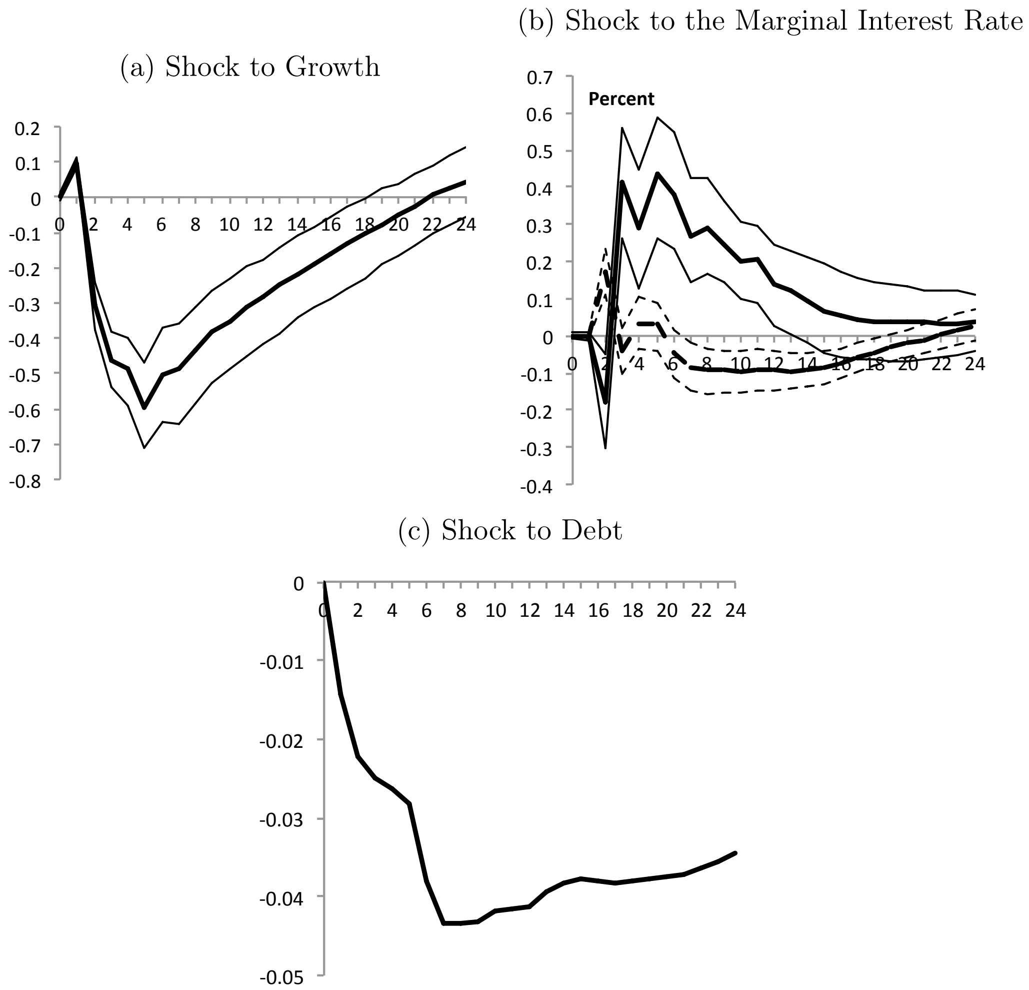


(c) Shock to Debt



Note: The figures shows the mean responses. The shocks are set to be a one percentage point increase in th primary balance (panel a), a one percentage point decrease in growth (panel b), and a ten percentage points increase in debt (panel c).

Figure 4.A.2: Responses of the Primary Balance to different shocks



(a) Shock to Growth

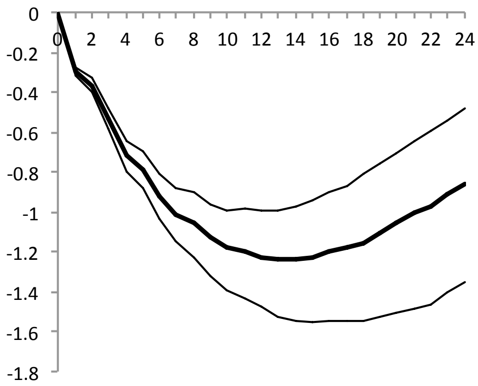
(b) Shock to the Marginal Interest Rate

(c) Shock to Debt

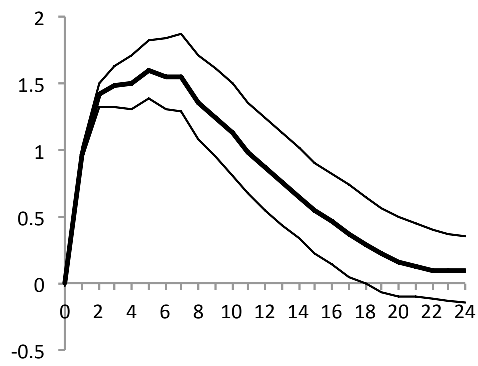
Note: The figures shows the mean responses. The shocks are set to be a one percentage point decrease in growth (panel a), a one percentage point increase in the marginal interest rate (panel b), and a ten percentage points increase in debt (panel c).

Figure 4.A.3: Responses of Debt to different shocks

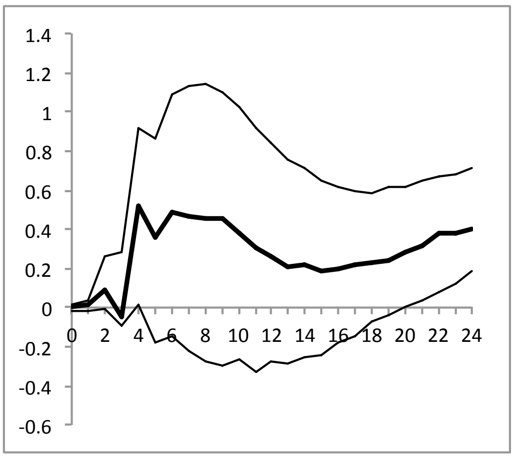
(a) Shock to the Primary Balance



(b) Shock to Growth

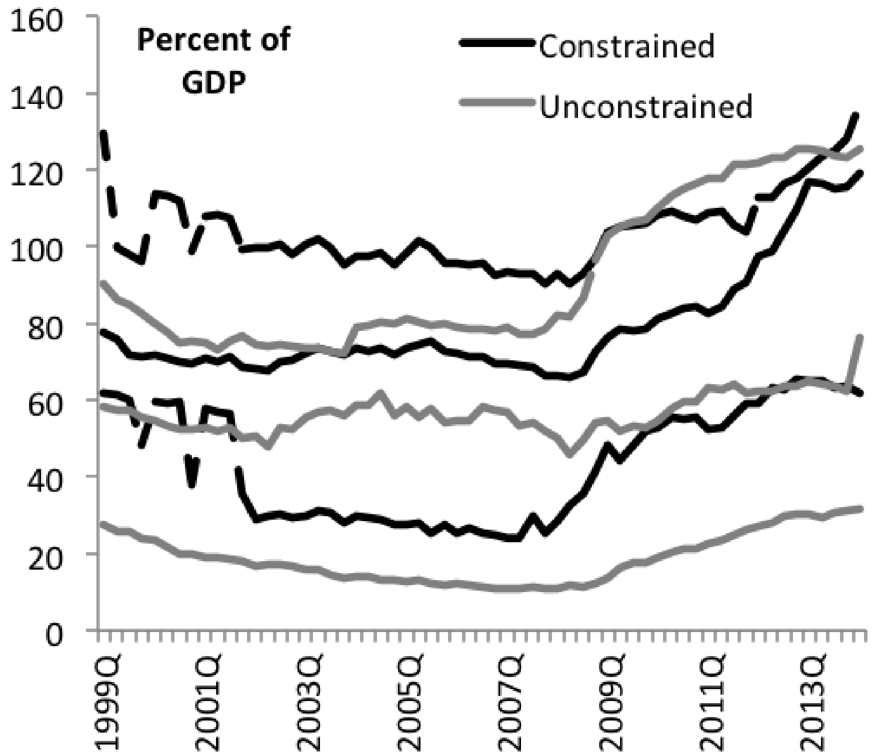


(c) Shock to the Marginal Interest Rate



Note: The figures shows the mean responses. The shocks are set to be a one percentage point increase in th primary balance (panel a), a one percentage point decrease in growth (panel b), and a ten percentage points increase in debt (panel c).

Figure 4.A.4: Median debt levels (with max and min values)



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Ehrenwörtliche Erklärung

Hiermit erkläre ich, dass ich die vorgelegte Dissertation auf Grundlage der angegebenen Quellen und Hilfsmittel selbstständig verfasst habe. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, sind als solche kenntlich gemacht. Die vorgelegte Dissertation hat weder in der gleichen noch einer anderen Fassung bzw. Überarbeitung einer anderen Fakultät, einem Prüfungsausschuss oder einem Fachvertreter an einer anderen Hochschule zum Promotionsverfahren vorgelegen.

Pablo Andrés Anaya Longaric
Berlin, 11. Mai 2020

Liste verwendeter Hilfsmittel

- Matlab 8.1.0.267246 (R2015b)
  - Optimization Toolbox
  - Symbolic Math Toolbox
  - Statistics Toolbox
- Dynare 4.5.7
- Eviews 9.0
- Stata 15
- Microsoft Excel
- LaTeX
- Siehe auch Literatur- und Quellenangaben